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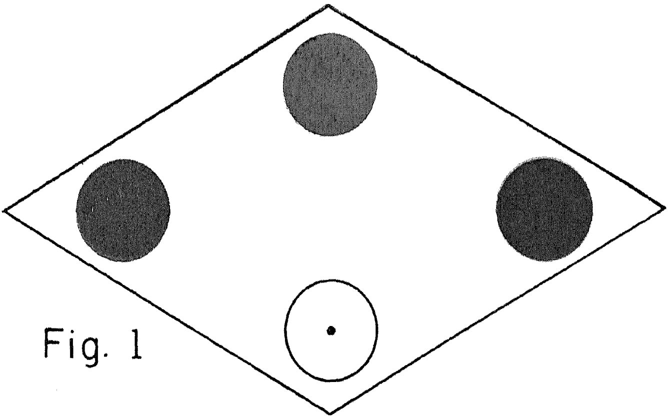
Color in decoration and design.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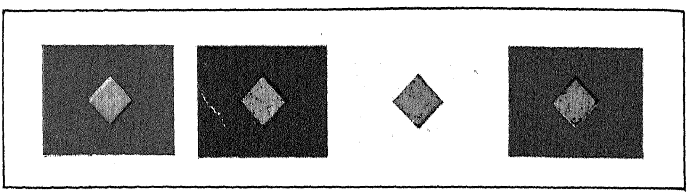
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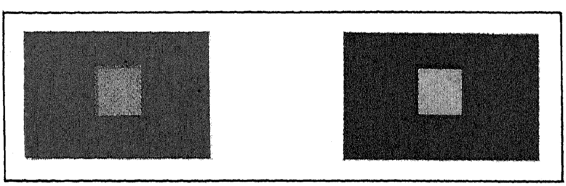
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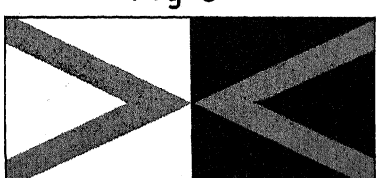
Fig. 4

COLOR IN DECORATION AND DESIGN

By
FREDERICK M. CREWDSON
Author of
Spray Painting, Industrial and Commercial

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PREFACE

The basic principles which underly the art of color, and which must be considered in the creation of either a simple color arrangement or a masterpiece of color technique, are fully dealt with in the following pages. Harmony and discord, as well as relationship and contrast, are considered in accordance with the impressions produced by color upon the mind and senses. Ideas which vitally concern the application of color to artistic, commercial, and industrial problems, are presented in the simplest of terms and in line with the most modern trends.

In writing this book, my object has been to gather together the most authentic material available regarding color and to present it in a thoroughly practical manner, unencumbered by technicalities. It will prove invaluable to the one who seeks to intelligently understand what the great artists and colorists have recorded, and who desires to express himself in the language of color. Particular emphasis is laid throughout upon the personal aspect, since color is a vital and intriguing experience in the life of every normal individual.

The simplicity of the language used, and the general treatment of the subject, should make this book invaluable to artists, art teachers, color specialists, fashion designers, decorators, printers, craftworkers, sign and display designers, and all others who have to use color in any way.

FREDERICK M. CREWDSON.
Rochester, New York.

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INTRODUCTION

A practical knowledge of color is important in the various avocations of life, and a nice discrimination of it is a source of great pleasure to the mind. The possession of a keen sense of color increases the intellectual and even the literary capacities of an individual. Poets and writers have been stimulated to write many a delightful phantasy and subtle metaphor through having observed the action of color in nature's ever changing pageant.

Color has a definite effect on the emotions, and influences to a marked degree the health of individuals.

Color, however, is not only cultural as it affects the aesthetic and emotional inclinations of people, but in a broader sense has its greater use in the benefits that it offers through the medium of its application to the things of everyday life. Almost everything that man consumes, wears or enjoys is brought to his attention through the medium of color.

In the sciences also, color finds an important place. For example, in biological, chemical and spectroscopic research many delicate questions of color enter.

There is no study that gives such thrilling returns as that of color. As the student advances from the point where the enjoyment of color was limited to a state of simple visual stimulation and response, old habits of thought are broken and he becomes aware of a fuller appreciation and finer discrimination of harmoniously balanced tones, systematically arranged hues and subtle color textures.

The simplest way to study anything is to find its elements, essentials or first principles. The simpler

these elements are, so much easier they will be to comprehend. In the study of color as presented in this book, the "Rule of Three" — the subdivision of anything into three elements, will be brought to the attention many times.

Three Essentials.—There are three essentials that enter into the phenomenon called "color." These are:

1. Light . . . . The unfolder or source of color.
2. The Eye . . The beholder or receiver.
3. The Mind . The interpreter of the sensations received through the eye from the source of color.

Light, the Unfolder.—"And God said 'Let there be light'; and there was light." Light is, and always has been, the first desire of man. Whether radiating directly from the sun, a fire or a lamp, or emanating as reflected light from a non-luminous body such as a rock or a flower, it has always been his most intense and dramatic experience.

Eye, the Receiver.—When light enters the eye and is translated into sight, something happens which affects the greater part of the consciousness of man. It creates for him a universe of form and color which becomes the very foundation of his physical and spiritual experience.

Mind, the Interpreter.—Light consists of vibrations. When the vision rests upon an object, the eye receives certain vibrations and sends them along a marvelous nerve system to the brain. When the brain responds to these vibrations your mind begins to think and analyze the message sent in from the eye — you begin to "see." Without the mind you cannot understand what your eye has seen. If the mind fails, the response to the vibrations fails. In the mind lies the complete thought, and you can only see as your mind thinks.

Light, eye and mind are all essential to the sensation of color. They must co-ordinate perfectly and

flow into each other in the right order. When this uninterrupted sequence takes place in the life of an individual he becomes overwhelmed with an infinite consciousness filled with visions of mountains, skies, seas and living things — a consciousness that is able to transmute into thought the black print on the white pages of this book. He is able to register his impressions of the resulting sensations, to analyze them and to utilize them in a thousand and one different ways in his everyday life.

Three Manifestations.—Color is made manifest in three different ways;—

1. Nature's pure and unapproachable color, made without the help of man, and displayed on every hand.
2. Man-made color, as presented in colored pigments, dyes, inks and artificial lights.
3. Man's use of color in the decoration of homes and public buildings, in displays, advertising, personal adornment, etc., as well as for creating certain emotional effects.

Three Approaches.—There are three recognized systems of color study:—

1. The physical system, which is concerned primarily with the nature of light, the spectrum and wavelengths.
2. The pigmentary system, which has to do with the manipulation of colored pigments, dyes, inks, etc.
3. The psychological system, which approaches the art of color as an intriguing sensation in human experience.

In the following pages all aspects of color will be considered and given their rightful place. However, the psychological aspect, because of its importance in the experiences of everyday life, will receive much consideration. Dominating all our study of color will be the field of color perception.

Personal experience of color draws its beauty from the marvelous co-operation of the three essentials — Light, Eye and Mind. In our desire to become better acquainted with color we must first of all accept the tangible realities of the world of color perception — personal color experiences — as our starting point and finishing line. However, we must not attempt to detach the relationships between color phenomena and the underlying physical, physiological, psychological and chemical processes. The "whence" of the problem must receive just as much interest as the "why" and the "what" before a proper knowledge of color can be attained.

CHAPTER ONE

AN INTRIGUING SENSATION

A world without color! Can anything more monotonous be imagined? But, thanks to an all-wise Creator, color is everywhere. In the green running sea, brown earth, verdant meadows, yellow jonquils, rose tinted clouds, sunset skies,—in these and numerous other ways, nature presents her glorious color rhythms. Each season of the year has its own matchless palette, but for sheer beauty there is nothing to compare with the gayness of June coloring as displayed beneath a clear sun in an azure sky when the first roses blend with the blazing azaleas, and the subtle gradations of greens all mingle into one perfect harmony. Even the orioles and the robins seem freshly painted in June. Burnished and polished by the cool mists and rains of Spring, every flower, leaf and blade glistens as though fresh from the workshop.

Contrasted with June's rich, rare colors, even the sober tones of November present an abundance of interesting rhythms of grayed colors in the frost-bitten grass, in dry withered weeds, and in leaves and branches from which the life-giving sap has been withdrawn.

Nature's color is alive and ever changing, but, for the moment it shows us a vision of beauty that is something more than a temporary sensation. Because of color's irresistible influence upon the mind of man it has aroused within him an impelling desire to reach out and recreate nature's handiwork to satisfy his needs. Artists are ever striving to produce with pigments the complexity, gradation and vitality which are ever present in nature's coloring. Hence, the con-

sidering of pleasing combinations of color has entered into almost every phase of decoration and design.

The resourceful, flexible genius of the color chemist has resulted in the creation of beautiful pigments and dyes like imprisoned light having the luminescent quality of the rainbow. The miracle of the coal tar dye has not yet finally been unfolded but continues to grow more and more interesting. Today is incalculably more colorful than yesterday. Color is loved and understood as never before.

Color Psychology.—Scientists declare that color can produce profound changes in the mind. Because of the strong influence played by color on the emotions, it has been prophesied that doctors will eventually give color prescriptions along with medicine. In fact, a noted Swiss hospital has a series of "rainbow solariums" — sun rooms inclosed in tinted glass. Each color is employed in the treatment of a specific mental ill. Gaudy color schemes act as a stimulant in some nervous disorders, while hypersensitive, neurotic persons find a soft blue very soothing.

The emotional and mental reaction of individuals to color has been capitalized on with remarkable effect by the San Fernando Heights Orange Association, San Fernando, California. It had been observed that the system of piece-work packing tended to wear down the nervous system of even the healthiest employees. The manager of the Association, in looking around for a remedy for this, concluded that if the drab interior of the packing plant were brightened up with color it might cut down on fatigue and nerve strain. A color specialist was consulted regarding this and he agreed to transform the plant, both in productive output and employees comfort, if given a free hand.

The result was amazing! To quote from the Los Angeles Times:—"Violet machinery! Yes sir, I said Violet! Oranges trickling from mustard-yellow grad-

ing tables, rolling on conveyor belts in peacock blue troughs. Girls in two-tone tan uniforms, piped with Persian orange, picking oranges off Persian orange tables divided by upright partitions of mustard-yellow. This all sounds like an artist's wild dream of art in industry. Nevertheless it is the latest development in color treatment of an industrial plant — and the workers like it! They freely admit that they do not get so tired now."

Many factories instead of having the interior walls painted all over with white, have had both the walls and machinery painted in tones of green which are not so tiresome to the nerves. Because of this the employees have produced more and better work.

Considering, therefore, that color has a very definite and profound effect on the mind and body, it should be dealt with primarily as a matter of human experience, emotional response, and mental judgment. To comprehend its mysteries and fascinating peculiarities, the science of psychology, which bases its findings on the studied responses and mental reactions of individuals to prescribed conditions, must be taken into account.

Color Moods.—Color is intimately associated with our various moods and is the cause of some of our most exquisite sensations. It can stimulate the imagination, develop the intellectual faculties and give pleasure and refreshment to the mind. It is also capable of arousing feelings of grief and sadness. Temperament, habits and past experiences are important factors which are responsible for the reaction of individuals to color.

Red, because of its association with fire, suggests warmth, passion and love. It has been observed to be stimulating, but soon excites and irritates, often causing nervous headaches. Yellow and orange suggest sunlight, brightness and liveliness. They are cheerful

and tend to induce the joy and happiness associated with sunshine. Yellowish green, the color of young trees and verdant meadows in Spring, suggests growth, life and the freshness of youth. Green is restful, and because of this is being used successfully for the decoration of rooms that are used for relaxation. Blue suggests loyalty, and is used in this sense in the expression "true blue." Because of its association with the sky and distance it gives the feeling of space and coolness. Violet and purple are regal and dignified, but because of associations with mourning they tend to convey feelings of sadness and melancholy.

Warm and Cool Colors.—Colors also possess the power of suggesting warmth and coolness. Fire, sunshine, and the healthy glow of vitality on the body after doing some brisk exercise, are all associated with warmth. The colors that produce impressions of stimulating warmth are those which range from red through orange to yellow. The sky, distant hills and mountains, great lakes, and the ocean are usually bluish in appearance and convey feelings of coolness and space.

Apart from such associations of warmth and coolness in objects, colors of themselves tend to arouse emotional impressions in the mind. If a variety of colored objects were assembled together and a number of people were asked to choose individually the colors that suggested warmth and those that suggested coolness, they would unanimously choose those which approach red as warm, and those that tend toward blue as cool.

These associations of warmth and coolness are not "just imagination." It has been proved by experiment that certain colors do actually have the power to absorb heat and retain it.

A color test, made at the laboratories of the paint and varnish industry in Washington, D. C., utilized

small tin cans and thermometers. Twenty cans were painted on the outsides in various colors, ranging from white to black and including a wide variety of colors at different intensities. The cans were then filled with water and a thermometer inserted in each. Next, they were set out on the roof of the laboratories in the hot, blistering Washington sun. It wasn't long before the thermometer in the can that was painted black registered 150 degrees F., while the thermometer in the white can was 30 degrees lower. The other colors ranged in between these two points.

Another recent color experiment that gave proof that colors have the power to absorb and hold heat was tried with three wooden paddles. One was painted black, one light chrome green, and the third, white. These were laid on top of a snowdrift on a bright, sunshiny day in the middle of winter. After several hours it was observed that the black paddle, which absorbed and retained most of the heat, had melted the snow beneath it and had sunk deep into the drift. The white paddle had absorbed very little heat and was still on top of the drift. The green paddle had sunk only half as far into the drift as the black one.

Advancing and Receding Colors.—Some colors seem to be unobtrusive, — they appear to recede and give the effect of distance, while others seem to advance toward the eye. Warm colors appear to advance while cool colors seem to give the effect of distance. Psychologically, this may be due to the fact that warm colors are associated with sunlight, and cool colors with space and distance. Then again, the projecting portions of objects usually catch and reflect the warmer tones of light, and the receding portions the cooler elusive tones. Pure colors are usually more advancing than grayed colors.

The illusion of advancing and receding colors can often be observed with startling effect when changing

colored lights are thrown upon a multi-colored theater curtain. Occasionally, as one colored light succeeds another a part of the design on the curtain will appear to jump forward and be suspended in space a short distance in front of the remainder. When the color of the light changes, that portion recedes and takes its place again.

Weight in Color.—Another interesting feature of color is its power to suggest weight. It is a recognized fact that dark colors seem heavier than light ones. Because of this quality of weight possessed by colors a certain manufacturer had some boxes which were in constant use repainted green rather than dark gray as he found that his employees were less conscious of the heavy burden of lifting and carrying the green boxes.

The factor of apparent weight in colors may be capitalized upon very effectively in rooms which are extremely high by painting the ceiling in darker and warmer tones than is usually practiced. The heaviness of the darker tone together with the advancing characteristic of the warmer tone gives the illusion of nearness to the beholder and make the ceiling appear lower. Vice versa, low ceilings may be made to appear higher by painting them in very light, cool tones.

Under red light the average person will tend to judge weights as heavier. Under green and blue lights there is a tendency to judge them as lighter.

Yes — color has the powers of suggesting warmth, coolness, and distance, and it takes men skilled in the development of these potentialities to make use of them. Poorly executed color work can do much to detract from the winsomeness of a color scheme.

Developing the Color Sense.—Color says things, does things and sells things. The intelligent employment of color demands a knowledge of the principles of harmonious and effective coloring. In the search

for this knowledge the chief concern seems to have been with the nature of light, wave lengths and the manipulation of colored pigments. Color, however, is more than merely physical and esthetic responses. It is an intriguing sensation playing an immensely important part in the life of man. Because of the emotional and psychological aspects of color much sound judgment must be exercised in its practical application. The more one develops the faculties of color perception, and the more acute the ability to discriminate between the finer tones, the greater will be the pleasure derived.

Choice of colors, either for artistic or utilitarian purposes, is dependent upon the degree of development of the color sense. Systematic practice in any art tends to develop the faculties that are necessary for its existence. It naturally follows therefore, that if the color sense is developed, all those arts into which color finds a place will benefit. The artist with an intelligent understanding of color is able to create more effective pictures; the craftsman with his color faculties increased produces finer, and more tastefully designed displays, posters, signs, interior decorations, ceramics, etc.; the merchant who judiciously introduces color into the goods he sells increases their attractiveness and sales appeal.

CHAPTER TWO

THE COLORIST'S VOCABULARY

Our fullest enjoyment of the beautiful things we experience daily is more or less dependent upon the ability to find words to describe them to others. When it comes to describing colors there is no lack of words, in fact, there are too many whose meaning is so inconsistent that one has scarcely any other alternative to avoid misunderstanding than to produce samples of the colors under discussion. Color names such as biscuit, cream, cinnamon, rust, champagne, sand and cafe' au lait (coffee with milk), may be placed in this class. These names may be very picturesque, and may be very effective from the psychological standpoint of appeal, nevertheless they are somewhat confusing and vague in meaning when an accurate description is essential. For example, the color of coffee and milk depends upon the content of milk or cream.

Besides the individual names which are associated with colors there are terms which aim at describing the qualities or attributes of color that are equally indefinite and confusing in meaning. All this inconsistency tends to make the subject very perplexing to the average person. It is difficult for him to speak really intelligently about it and hard for the listener to comprehend with any degree of certainty the meaning that the speaker intends to convey.

Color nomenclature therefore, needs a system of standardized names employing a minimum of arbitrary words, that links variations of color with recognized factors of experience, and lends itself to consistent use in commerce and art. A number of color systems have been invented in which colors have been standardized

and fixed by forms of physical measurement so that it is possible, by merely stating certain letters and numerals, to give an exact and complete description of a color. The more important of such systems will be dealt with later.

In its widest sense, the term "color" refers to the sensations caused by certain qualities of light by which the eye recognizes, and the brain interprets, the form and nature of things. Because color is a personal sensation it naturally follows that the most logical terms to use in describing color and its qualities are those that are purely psychological and concerned with everyday experience.

Psychology is the study of man as an acting and knowing individual. It inquires into the conditions of man's actions, how he can do things to best advantage, and the reasons for his successes and failures. It is also interested in determining how the individual becomes aware of external things, how he retains his experiences and impressions and recalls them at will, how he makes decisions, and the occasions and origins of his feelings and emotions.

Colorless and Color Sensations.—Our visual sensations comprise both colorless (achromatic) and color (chromatic) sensations. The colorless group ranges from the most blinding white to the blackest black, and every gray sensation between the two. Color sensations include all the spectral hues which are afforded by the analysis of daylight, in every degree of brightness and saturation, as well as other hues such as the purples, magentas and browns, which are man made and not found in any portion of the solar spectrum.

From the psychological standpoint of sensation there are six distinctly different visual sensations. These are four fundamental color sensations — red, yellow, green and blue, and the colorless sensations — white and black.

The Solar Spectrum.—Almost everyone is familiar with Sir Isaac Newton's experiment which illustrates the breaking up of daylight into its component parts. If the reader so desires he may carry out this experiment for his own enlightenment in the following manner. On a bright sunny day, cover the window of a room with some dark material so as to shut out all light. Then, pierce a small hole in the material, thus allowing a sharp beam of light to enter through this into the room. In the path of the beam of light place a triangular glass prism. This causes the beam to bend as it passes through the prism and also on emerging from it. The light beam, after passing through the prism, spreads out fanwise on emerging. If a white card is so held that this light falls upon it, a row of bright colors will be observed with red at one end and violet at the other. These colors are arranged in the following order — red, orange, yellow, yellowish green, green, greenish blue, blue, blue violet and violet. They pass imperceptibly into one another and are not marked off by sharp boundaries. This array of colors is known as the "solar spectrum."

Luminous and Non-Luminous Bodies.—Colors have their source in light. Without light we are in darkness and therefore unable to see what is before us. There are certain bodies such as the sun, a lamp, a lighted candle or a fire that radiate light of themselves and for this reason are said to be "luminous." We see luminous bodies because of the light they radiate. Most things we observe around us, however, are unable to give out light of themselves. These are said to be "non-luminous." When light falls upon non-luminous bodies they absorb some of the light rays and reflect, or throw back, the rest.

The waves of light emanating from luminous and non-luminous bodies spread out in all directions very much as the disturbances caused on the surface of a

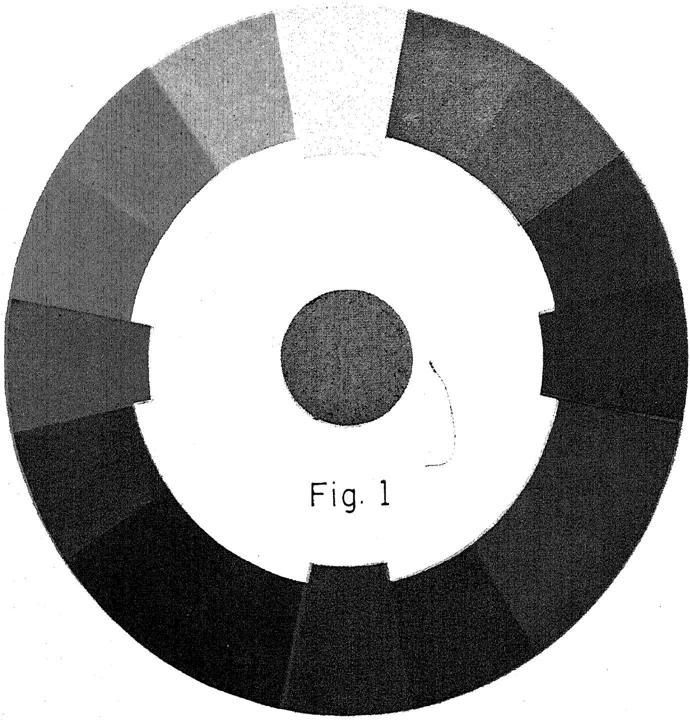


Fig. 1

PLATE 1

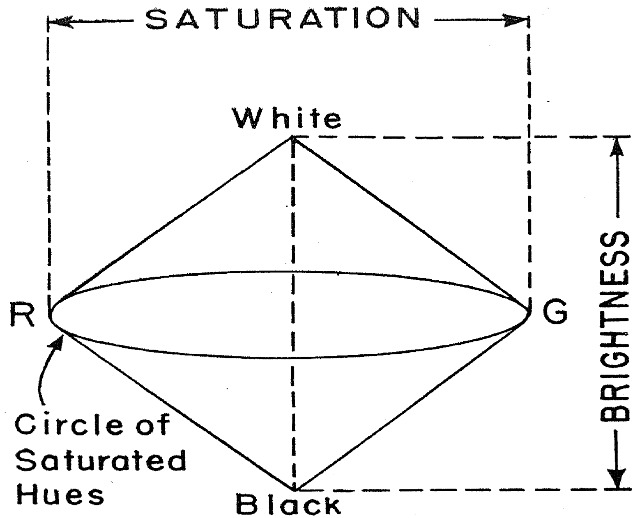


Fig.2

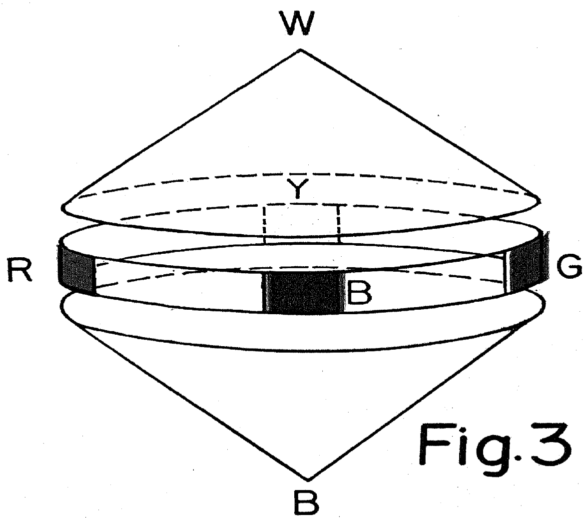


Fig.3

PLATE 1 (*Continued*)

pool of water when a pebble is thrown into it. When the light rays reach the eye, they pass through the lens and are focused on to the retina. The retina consists of numerous endings of nerves which are bundled together into what is called the "optic nerve." The optic nerve transmits the impression made on the retina to the brain and in some wonderful way we are able to "see."

Sensations of color are due to these light wave movements. A red box in ordinary daylight is red because it absorbs all the rays of light that fall upon it, except those that are red, which it throws off or reflects. These reflected red light rays are received on the retina, and the impression from them transmitted by means of the optic nerve to the brain. The brain analyzes the impression and "tells us" the box is red. A blue dress is said to be blue because it reflects blue rays and absorbs the rest. Surfaces that reflect all rays appear as white. Those that absorb all rays are said to be black.

The person with an inquiring disposition might ask the question—"What becomes of the rays of light that are absorbed by a surface?" The answer is—"They become changed from visible light rays to invisible heat." This fact was proved by the experiments with the colored cans and paddles described in chapter one.

Color Attributes.—There are three general characteristics to be considered in relation to a color, namely—Hue, Brightness and Saturation. They are the "attributes" of color.

Hue will be considered first. Observe the colors on Plate 1. There is some quality about them that makes it impossible to mistake one for another, as for example, blue for red, or green for violet. This quality is called the "hue." When we describe a color as red,

or yellow, or green, we are naming its hue. Hue might be described as the "colorful" part of a color. If on describing a particular green, that seems to have an excess of blue in its makeup, such a green is said to have a bluish hue; if yellow seems to be in excess, the green is said to have a yellowish hue.

Colors also have the attribute of "Brightness." The brightness of a color is the amount of light it reflects. Some colors reflect more light than others and are therefore said to be brighter.

Adding white to a color increases its brightness because white is brighter than any color. The addition of black to a color reduces, or lowers, its brightness because black is darker than any color.

The terms — luminosity, value, and brilliance, are employed quite frequently to describe the relation of a color to white and to black, but the term brightness is to be preferred because it is more straightforward and causes no confusion. Luminosity is vague. Brilliance can imply such characteristics as glitter, sparkle and sheen, which are quite different from brightness. A diamond possesses brillance, but this is a quality quite unlike brightness. The term — value, is a rather excellent word which is used with much meaning by artists, but by others is not generally understood as implying brightness.

Colorless sensations also, have the quality of brightness. If a series of grays be vertically arranged in order, with the deepest of blacks at the bottom, the whitest possible white at the top, and the light and dark grays between them in order with the darkest at the bottom and the lightest at the top, we would say that they are arranged in the order of their relative brightness.

"Saturation" is the term used to describe the degree of difference of a color from gray. It implies the limit

of the "colorful" part of a color. An analogy to this may be found in describing the relative humidity of the air in a room. We say the air is saturated when the relative humidity is 100 per cent, that is, it contains all the water vapor it can hold under specific conditions.

Those colors that are one-hundred-per-cent saturated are the spectral hues. The colorless sensations — white, black and gray, are considered as being at zero saturation. Colors become less and less saturated therefore, as they approach white black or gray. This is illustrated on Plate 1, Fig. 2.

The terms — intensity, purity and chroma are often used to describe saturation, but, although they imply pretty well what is meant, are rather indefinite.

Tint, Shade, Tone.—The addition of white to a color produces a tint. Black added to a color produces a shade. The word "shade" is greatly misapplied, and is often used where "hue" would be more appropriate. We sometimes hear certain light greens spoken of as "pretty shades of green," or certain light blues as "delicate shades of blue." Saturated hues and tints can hardly be correctly called shades, as this term necessarily implies darkness. Tone designates the brightness of a color. Colors are said to be lighter or darker in tone according to the amount of light they reflect.

The Psychological Color Circle.—If the solar spectrum be carefully examined it will be observed that near one end there is a red that is pure and has no resemblance to either blue or yellow. This particular red, because of its distinctive purity, is called "primary red." Leading away from it is a sequence of hues which become steadily less reddish and more yellowish until eventually a yellow is reached which has not the slightest trace of red in it. This is called "primary

yellow." Moving away from this yellow a new change of hue begins. The yellow gradually increases in greenishness until it finally arrives at a green that is neither yellowish nor bluish. This is called "primary green." Then comes another change from green through increasing bluish greens to a blue which lacks traces of either green or red. This is called "primary blue." The spectrum then fades away into the violet hues.

These four primary hues have a peculiar significance in our study of color. From them the psychologist builds his chart of hues called a "color circle." The colors red, yellow, green and blue are placed equidistant around the circumference. Between each pair of these is placed an intermediate hue which is the result of a mixture of them, thus giving a circle of eight hues —yellow, leaf, green, turquoise, ultramarine, purple, red and orange. These are called the "eight principal hues." For the purpose of creating an interesting circle of hues we again place between each pair of the principal hues another color made by an equal mixture of each pair. This results in a circle of sixteen hues, as shown in Fig. 1, Plate 1. The order of the hues in this circle is as follows:

Yellow

Yellow-orange	Yellow-leaf
Orange	Leaf
Red-orange	Green-leaf
Red	Green (sea-green)
Red-purple or Magenta	Turquoise-green
Purple	Turquoise
Purple-blue	Blue-turquoise

Ultramarine blue

There are in existence at the present time color circles with red, yellow and blue, and red, green and blue-violet, as the principal colors. One colorist, Munsell, adopted a color circle of five principal hues. The

modern psychologist, however, has proved without a doubt that a circle having four primary hues — red, yellow, green and blue, states the most convincing truths about color. Almost all textbooks on psychology show four-color charts based on facts of color vision rather than on what instruments record. After all, the average color problem is more concerned with the result of stimulation than with the nature of the stimulus itself. Many colorists, however, still adhere to the old ideas and stubbornly refuse to face psychological truths.

Analogous Colors.—Colors that are situated near to each other in the color circle are called "analogous colors." They resemble each other and for this reason are said to be related. Such colors have a particular hue in common. For example, red and purple are analogous colors because purple contains some red in its makeup. Purple and blue are also analogous colors because purple contains some blue in its makeup. However, red and blue cannot be considered as analogous because they do not have any hue in common, but, should they be used together with purple we would be quite justified in calling them analogous because the purple acts as a link between them partaking of some of the characteristics of both red and blue.

It is safe to say that analogous, or related, colors are not more than four steps removed from each other in the sixteen-hued circle illustrated on Plate 1.

Complementary Colors.—Hues opposite each other in the color circle are said to be "complementary." When complementary colors are mixed, the result is a neutral gray. Ultramarine blue and yellow are complementary, as are red and green (sea green). A straight line drawn from a color to its complementary passes through the center of the color circle. The point where

all such lines cross each other is called the "complementation point."

The Psychological Color Solid.—By means of a simple geometrical figure—a double cone, the three attributes of color can be graphically represented. This is illustrated in Figs. 2 and 3, Plate 1. All colors are to be imagined as lying between the boundaries of this figure. In this representation, the series of grays from black to white is symbolized by a line drawn through the center, or axis, of the "solid," as we call the double cone figure. White is at the upper end and black at the lower. In between these are graded the changes that occur from black to white—the grays. Colors are represented at points outside the axis, and the farther these points are from the axis the greater is the saturation of the colors. In the illustrations just described, the saturated hues are located at the widest part of the solid.

The brightness of a color is represented by its height measured from the base of the solid. The higher the color is the brighter it will be. An examination of the color solid will reveal that the widest part, the part where the saturated hues are located, is just halfway between black and white in the brightness scale. Because of this, all saturated hues are considered as being at intermediate brightness.

A line drawn parallel to the axis of the solid represents a brightness series in which the colors have the same hue and saturation but differ in brightness. A line drawn at right angles to the axis of the solid at any place stands for a series of colors which have the same brightness and hue, but differ in saturation. Drawing a circle of any size concentric with the axis indicates a series of simple hues unchanging in brightness and saturation.

Let us again examine the solid. As we move along its surface, from the widest part to the point marked

'white,' we leave behind the realm of saturated color and approach more and more to pure white. As the amount of white increases, the amount of saturated color decreases. In this manner we enter the realm of increased brightness, or tints. Again, moving from a saturated color towards black, we find that as the amount of black increases the amount of saturated color decreases. In this way we enter the realm of lowered brightness, or shades. If, instead of moving towards either white or black, we decide to move from saturated color to the central axis of grays, it will be observed that as the amount of saturated color decreases, the amount of gray correspondingly increases. In this way we enter the realm of grayed color.

Rotating Disc.—For the purpose of demonstrating the effects of visual color mixture, many instruments have been devised. The most popular of these is a rotating disc, about five inches in diameter, mounted on a shaft which is made to revolve at high speed by means of a small electric motor. The rotator disc is marked off in degrees from zero to one hundred along the outside edge, as illustrated on Plate 2, Fig. 1.

Colored paper discs about four inches in diameter, each having a hole pierced in the center to accommodate the shaft of the rotator, are the mediums by which colors may be mixed and measured. These discs are slotted along the radius, as shown on Plate 2, Fig. 2, which makes it possible to thread them into each other so that they overlap and allow variable proportions of each color to be exposed. When the colored discs are made to revolve at high speed, the patches of color cannot be seen separately by the eye, but become mixed by virtue of a certain confusion in the responses by the retina, and appear as a single hue. These discs are exceedingly useful to the study of color analysis and the synthesis of hue sensations. They are often referred to as "Maxwell's Discs."

Small hand spinning tops may easily be made to answer the same purpose. They are constructed by fitting a matchstick tightly through the center of a cardboard disc about 2½ inches in diameter. Colors are painted on the surface and the top then spun by a quick twist of the thumb and finger.

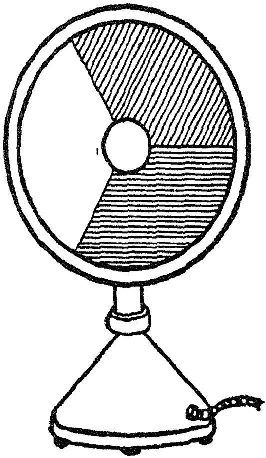


Fig. 1

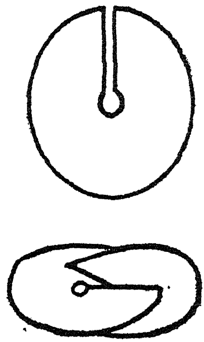


Fig.2

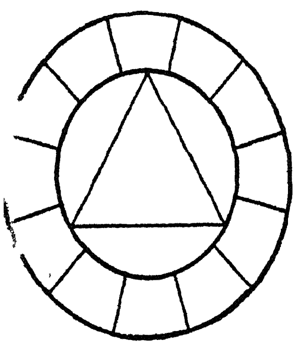


Fig.3

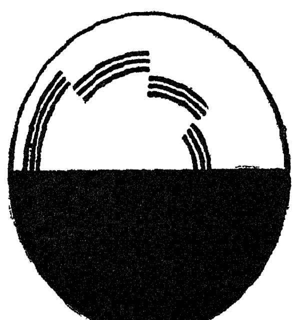


Fig.4

PLATE 2

CHAPTER THREE

GENERAL COLOR THEORY

In discussing some of the most familiar theories of color it is very necessary that we understand the distinction between colors and colored pigments. Strictly speaking, the term "color" is applicable only to those definite experiences or sensations called forth by stimulation of the eye by light or radiant energy. Pigments, dyes, inks, and so forth, are "colorants." They modify light by absorbing some of its components and reflecting others.

First Beginnings.—From ancient times the use of colored pigments in decoration has been a recognized fact. The oldest known writers who attempted to comprehend ideas associated with colors were Greeks and Romans. They named only black, white, yellow, and red distinctively as colors. There were, however, on early Egyptian works blue and green colored pigments, but these were never described as such, and were classed with black. The Egyptians were credited with employing the first artificially prepared pigment. This was a blue-colored copper-sodium silicate still known today as Egyptian Blue. Later other pigments, notably yellow and red made from natural earth, were used, the binding media beings gums and waxes. Powdered charcoal was used for black.

The middle ages saw the introduction of colored pigments made from berries, woods and roots. In the eighteenth and early nineteenth centuries, due to the great advances in chemical research, such pigments as Prussian blue, emerald green and the various derivatives of chromium made their appearance. It was in the latter part of the nineteenth and early in the

twentieth centuries that saw the greatest advances, due to the discovery of coal tar dyes. And the end is not yet in sight! The miracle of the coal tar dye has not yet been finally unfolded. Dyes and pigments that rival the grandeur of the rainbow are constantly being presented.

It is remarkable that, even though the knowledge of these numerous pigments and their application was highly developed during these years, few attempts at systematization were made. Aristotle, the ancient Greek philosopher, developed a theory, which persisted for some eighteen centuries, that colors were blends of light and dark, or white and black. Then in the seventeenth century Descartes, the famous French philosopher, abandoned this theory and spoke of the "ether," or "plenum." He believed that light was a pressure transmitted through space, and that different colors had different speeds. In this same century Robert Boyle, one of the founders of modern chemistry, also believed in the existence of ether and was convinced that colors were produced by reflection and refraction. However, it was not until the science of physics intervened that the possibility of an accurate understanding of the phenomenon of color became evident.

Sir Isaac Newton (1642-1727).—The first advance was due to Newton who discovered the connection between the refraction of light and color. He demonstrated by means of a triangular glass prism, that white light which hitherto was assumed to be homogeneous could be split up by refraction into an indefinite number of different varieties, distinguished by their differences in degrees of refraction. The light that was least refracted caused the sensation of red, then in order followed orange, yellow, green, turquoise blue, ultramarine blue, and violet.

Newton believed that light consisted of atoms or particles which spun about and whirled through space. The atoms of red were large in size, those of violet small, and all others varied correspondingly in size according to their relationship with either red or violet. This conception was called the emission theory. Later on it was found that light travelled in waves, and for a while the ideas of Newton were discredited. Today, however, scientists admit both an atomic structure and a wave structure in light. According to Einstein, light has mass, actually exerts weight or pressure, and is bent by the force of gravity. This indicates that light has substance to it, and has what is called a corpuscular structure as well as a wave structure. In other words, light is matter, and matter can be made to excite light.

Newton is accredited with the idea of bending the above mentioned sequence of seven colors in the form of a circle with red and violet joined together. The first known person who attempted to utilize Newton's seven-color circle in actual practice was a German copperplate engraver named Le Blond who, about the year 1730, prepared color prints in which he employed Newton's seven colors. Later he discovered that he could obtain approximately the same result with only three colors, namely red, yellow, and blue. About the same time a Parisian named Gautier arrived at the same solution.

Brewster Theory.—The use of these three colors in printing was soon transferred to other branches of technology. About 1737, Dufay described how by mixing two or more of these colors almost all hues could be prepared for use in the dying of yarns and fabrics. This three-colored doctrine, making red, yellow and blue the primary colors, is very prevalent to this day, especially amongst artists, decorators and designers.

Sir David Brewster, Arthur Schopenhauer, and M. E. Chevreul were enthusiastic supporters of this doctrine which is now popularly known as the Brewster Theory.

Red, yellow, and blue were chosen as the primary colors because they were in themselves considered as elements, and could not be made by any mixture of pigments. When placed equidistant around the circumference of a circle they form the points of an equilateral triangle. Between each pair of these is an intermediate hue called a secondary color which results from the mixture of two colors next to each other. This gives a circle of six hues. Between each pair is again added another color made from the mixture of them and a twelve-hued circle is thus formed. This is shown in the diagram on Plate 2, Fig. 3. As just stated, mixing together two primary colors gives a secondary color. For example, mixing red and yellow results in orange, mixing blue and yellow gives green, and mixing red with blue results in violet or purple. Orange, green, and violet are secondary colors.

Colors directly opposite each other in the color circle are said to be complementary. The following are the complementary colors according to this theory:

Yellow	is	complementary	to	violet
Yellow-green .	"	"	"	red-violet
Green	"	"	"	red
Blue-green . . .	"	"	"	red-orange
Blue	"	"	"	orange
Blue-violet . . .	"	"	"	yellow-orange

The mixture of complementary pigment colors always gives a muddy, blackish gray.

The color circle of the Brewster Theory finds its greatest use in the determination of the results of colorant, or colored pigment, mixture. However, when used as a chart for plotting color harmonies it has

many defects, especially in the matter of complementaries, as we shall see later in this chapter.

Visual Perception.—What happens when we "see" an object? The rays of light reflected from the object are "caught" by the eye, and after being converged or bent by the cornea, pass through the pupil into the lens. The iris, which surrounds the pupil, is an adjustable diaphragm which makes the pupil smaller in strong light so as to protect the retina, and makes the pupil larger in weak light. The lens is actuated by the ciliary muscle, sometimes called the "muscle of accommodation," which shapes the lens and causes it to focus the object upon the retina. Whether the object be near or distant, the power of the lens may be changed in a fraction of a second to keep the image in perfect focus upon the retina. The retina is the light-sensitive receptor organ. It is an intricate nervous layer spread over the back of the interior of the eyeball. The inside wall of the eye is lined with black, which absorbs the light that would otherwise be reflected back and forth within the eye thereby confusing and dulling the image on the retina. Cameras are lined with black for the same reason. The eyeball itself is filled with a transparent gelatinous substance, which serves to keep it expanded and in shape, and also to hold the retina in place.

Part of the retina is made up of cells about 1/1000 of an inch long and 1/10,000 of an inch in diameter shaped like rods and cones. The cones are shaped something like a nine-pin. The shape of the rods is somewhat as the cones would be if they were stretched lengthwise and thus be made longer and narrower. Light falling upon the rods and cones causes some photochemical change in them which produces electromagnetic impulses. These are caught up by the numerous endings of the optic nerve and transmitted by the latter to the sight cells in the brain. The optic nerve

is a cable of nerve fibers extending from the eyeball, through an opening in the bone of the eye socket, to the base of the brain.

The rods are the receptors for brightness, while the cones are believed to be responsible for color vision. At the fovea, which is a small depression in the retina straight back from the pupil, only cones are present. The fovea is the center of clear vision, and here fine details of objects are best perceived. Outside the small central region, rods and cones are intermingled, with fewer and fewer cones the farther away from the fovea they go. Likewise, the farther away from the fovea, the poorer is both form sense and color sense, which fact leads to the conclusion that response to both form and color depends mostly upon the cones.

In its last resorts, however, the perception of form and color must depend upon changes in the cells in the sight centers of the brain. The eye is the receiving organ but it is the brain which actually does the "seeing." Light, the source; eye, the receiver; brain, the interpreter!

The best known theories of color vision are the Young-Helmholtz, Hering, and the Ladd-Franklin theories. All are physiological theories. The Young-Helmholtz and Ladd-Franklin theories approach physiology by way of physics while the Hering theory uses the way of psychology.

Young-Helmholtz Theory.—This theory was first propounded by C. E. Wunsch and later established experimentally about 1806 by Thomas Young, the English Physician, Physicist, and Linguist. Young was the first to establish the undulatory theory of light on a firm basis, and is generally looked upon as the founder of Physiological Optics. His trichromatic theory of color vision was later revived and greatly developed by Helmholtz, the celebrated German mathematician and scientist, who had great regard for

Young. On account of the contributions of Helmholtz, the theory is known as the Young-Helmholtz theory.

This theory advances the idea that white light is made up of three primary bands of light rays consisting of red, green, and blue-violet, and that any color can be matched in hue and brightness by a proper mixture of these three colors.

In its original form the Young-Helmholtz theory supposed that three sets of nerve fibers existed in the eye, each of which was sensitive to light waves of a certain length. However, in a later form of the theory, three photochemical substances replace the three sets of nerve fibers. The first photochemical apparatus is strongly stimulated by long light waves and produces the sensation of carmine red; the second apparatus responds most strongly to waves of medium length and produces the sensation of green — a slightly yellowish green; and the third is most sensitive to short waves and generates the sensation of blue-violet which is somewhat similar in hue to ultramarine. In other words, the red apparatus is acted upon when stimulated by red light rays, the green by rays of green light, and the blue-violet by means of blue-violet light rays. However, the red rays not only act upon the red-sensitive apparatus, but, according to this theory, also act on the other photochemical substances with much less energy. The same is also true of the blue-violet and green rays. They each act upon all three substances to some degree, but most powerfully on those especially designed for their reception.

When all three photochemical substances are excited simultaneously the resulting sensation is white. Grays are considered to be different stages in the intensity of excitation of the white producing substances. Black is said to be the absence of light.

According to the Young-Helmholtz theory, red, green, and blue-violet are considered to be the primary

light ray colors, because they are responsible for the previously mentioned three primary color sensations. Hues intermediate between these three are produced by the combined stimulation of at least two of the photochemical substances. A combination of proper amounts of red and green light rays cause the red sensitive and the green sensitive substances in the eye to be excited together and the sensation of yellow is generated. When the red and yellow substances are excited together the result is orange. A combination of yellow and green results in yellow-green. Blue and green produce blue-green. Red and blue combined in various proportions give violet and the whole series of purples that bridge the gap between the ends of the spectrum.

It is interesting to note that while it is possible to produce all other colors by means of light waves of a certain length or combinations of light waves, the purples can only be produced by combinations of light waves and never by waves of one specific length.

As before mentioned, a combination of proper amounts of the three primary light ray colors produces white light. If any color is taken from white light, the remaining colors combined make the complementary of that color. In other words, a color and its complementary make white light. Thus:—

Red . . . . is complementary to blue-green, (peacock blue)
Blue-violet . is complementary to yellow,
Green . . . . is complementary to red-violet, (magenta)

Hering Theory.—The greatest antagonist to the foregoing theories was Ewald Hering, German physiologist, born August 5th, 1854. He was best known for his work in physiological optics. He based his theory upon (1), the elementary nature of red, green, yellow, and blue, and also black and white; (2), upon

the visual relation of the complementary colors to one another.

Hering assumed that the retina-cerebral apparatus contains three fundamental receptors, or three chemical substances, which are decomposable by light, and which are the vehicles of reversible or antagonistic chemical reactions. They serve respectively for red and green, yellow and blue, and white and black.

The overworking and consequent breaking down of the chemical substance responsible for red, as by gazing at a red object, strengthens the green substance; breaking down the green substance through stimulation strengthens the red. The same thing happens with each of the other chemical substances. Breaking down the blue substance strengthens the yellow; breaking down the yellow substance strengthens the blue. Exposure to white breaks down the white substance and builds up the black; breaking down the black substance strengthens the white.

Hering's assumption that red and green, yellow and blue, as well as white and black have their origin in separate organs, is furthered by the fact that if one looks at any color, or black, or white, for about thirty seconds and then shifts the gaze to another surface, preferably white or light gray, the complementary of each will be observed. For example, looking steadily for about thirty seconds at a red spot on a white background and then moving the gaze to another white surface, a green spot will appear the same size and shape as the red one. This is called the "after-image." Green gives an after-image of red, yellow a blue after-image, and a blue a yellow after-image. (See Frontispiece). Hering assumed that the after-image was due to the fact that when the organ is excited in one way, recovery from the excitation evokes the complementary sensation.

This is somewhat different from the Young-Helmholtz trichromatic theory in which the reason for the after-image is said to be because one of the three photo-chemical substances has become fatigued through over action and the remaining two substances more powerfully stimulated.

Seeing that opposite chemical changes are involved in each of the three processes of the Hering theory it naturally follows that stimulation of both at the same time will produce a neutral sensation. This can be observed by spinning on a revolving disc proper amounts of the psychologist's red and green. The effect produced will be a neutral gray. The same result occurs when proper amounts of the psychologist's yellow and blue are spun on a disc. Spinning proper areas of white and black on the revolving disc also produces neutral gray. Because each member of a pair neutralizes the other member of that pair, each is said to be complementary to the other.

Red, green, blue, and yellow are called the "four primary color sensations." In actual hue they are a purplish red, a yellow that leans neither to orange nor to green—somewhat similar to light chrome yellow, a green having a bluish hue and called sea-green, and a blue similar to ultramarine. These four primary hues are spoken of as "invariables," so-called because they do not change in sensation over the entire surface of the retina. They appear either as pure color or neutral gray. Although the retina is sensitive to all visual sensations, yet only the center of it—the fovea, is sensitive to color. If small colored discs are moved from the outer boundaries of the visual field towards the center of the focus of the eye, and close to it, it will be found that invariables undergo no change, except from gray to color. Hues that are not invariables will change. Orange, which is not an invariable, will first appear gray, then will gradually change to a yellowish

hue until it reaches the center of vision where it assumes its correct hue. The visual primaries selected by Hering, and adopted by psychologists generally, will always appear either gray or pure color under these circumstances.

Ladd-Franklin Theory.—The theory advanced by Mrs. Ladd-Franklin, another outstanding personality in this line of research, also refers to a chemical substance supposed to exist in the retina. During the process of evolution, retinal receptors, probably in the form of some chemical substance, appeared. These were able to distinguish only between light and dark. or white and black. When the substance was broken down by white light, the products of decomposition reacted on the retinal receptors in such a manner that the sensation of white was produced. Absence of stimulation on the substance corresponds to darkness or black. Later, this substance became further specialized in such a way as to produce two different kinds of chemical change which gave rise to sensations of yellow and blue—one part being decomposed by yellow light, and the other by blue light. Simultaneous decomposition of the two produced a sensation of gray.

In the third stage of evolution, the structure of the component sensitive to yellow was divided once again so as to produce a substance sensitive respectively to red and green. As in the previous case, stimulation of one of the components of the chemical substance and the consequent breaking down of the corresponding component produces the characteristic hue sensation. When both are simultaneously stimulated the result is not gray as might be expected, but the original derivative—yellow.

According to the Ladd-Franklin theory, red-green color blind eyes are those which have only reached the stage at which the yellow-blue substance has devel-

oped. Totally color blind eyes have stopped at the light and dark, or white and black, organ of visual perception.

This completes a general review of the most widely accepted theories of color. Its object has been to show the findings of some of the world's greatest color scientists. The significance of these theories will be more keenly understood as we proceed with our study of this fascinating subject. Artists, physicists, physiologists, and psychologists have learned many things from each other, and each has contributed his share to our enjoyment and utilization of color.

True Complementaries.—Regarding the subject of complementaries, we find that there are many points of difference in the theories of Brewster, Young-Helmholtz, and Hering. An examination of the color circle shown on Plate 1, Fig. 1, will reveal many interesting points of difference from the theories of the artist and the physicist, especially in the matter of complementaries. In this circle of hues, a circle which by the way is based upon the visual relationship of colors and follows the proved findings of the psychologist, complementaries that are true to facts of vision and human experience have been verified and correctly located through the use of revolving discs and the phenomenon of successive contrast. Much will be said in the following chapter about the subject of successive contrast.

It has been proved by means of revolving discs that a red having a rather purplish hue, such as crimson or geranium, is the true complement of a bluish green called sea-green. Also, that a blue such as ultramarine is the true complement of a yellow whose hue is somewhat similar to light chrome yellow pigment.

When proper amounts of true complementaries are spun upon a disc, they extinguish each other and form

a neutral gray, and any variation in the amounts of each component will only show traces of these two complementary colors.

The physicist's and the artist's complementaries are not so well matched. For example, when certain proportions of the physicist's complementary red and blue-green, or the artist's complementary red and green are spun on discs, a gray will be produced, but, if there should be an excess of red a gray having a violet tone will result, or if there is an excess of the physicist's blue-green or the artist's green a bluish gray will be produced. With the psychologist's red (purplish) and green (sea-green) a perfect neutral will result, and any variation in the amounts of each will only show tones of red and green and never any other hue.

The color circle in Plate 1, Fig. 1, adheres to the proved findings of the psychologist and the physiologist in the matter of true visual opposites or complementaries. Ultramarine blue is not far removed from violet, but it forms the perfect complement to yellow which violet just misses. Again, a red with a slightly purplish hue and a green having a bluish hue form perfect complementaries which glow with a marvelous intensity.

The following are true complementaries as indicated in the color circle in Plate 1, Fig. 1:—

Yellow . . . . . is the true complement of ultramarine blue
Orange . . . . . is the true complement of turquoise blue
Red . . . . is the true complement of sea-green
Magenta . . . . is the true complement of yellow-green

Ultramarine . . is the true complement of yellow
Turquoise . . . is the true complement of orange
Sea-green . . . . is the true complement of red
Yellow-green . . is the true complement of magenta

CHAPTER FOUR

THE PERCEPTION OF COLOR

The sense of vision is curiously involved in a number of illusions and phenomena, due largely to the fact that the eye does not merely record the objects before it but actually creates effects in and of itself. Color perception is not determined solely by the amount and quality of the light rays that reach the eye, but involves the total situation in which the color is seen.

Successive Contrast.—If you look for a moment at a light from an incandescent bulb as it is being turned out, you will continue for a short period of time to see the image of it after it has actually been extinguished. This image is called a "positive after-image" because it is similar in appearance to the original. It is, however, much weaker. There is also a "negative after-image." This may be obtained by looking at a white, black, or colored figure for about thirty seconds and then turning the gaze to a medium gray background. After a moment's delay, a sensation develops in which black takes the place of white, white takes the place of black, while for the colored figure its complementary will appear. After-images are sometimes called "after sensations." A practical demonstration of after-images may be made by referring to Fig. 1 on the Frontispiece. Gaze for about thirty seconds at the center of any one of the colored discs, then shift your gaze to the center of the white disc where the complementary of the color you have been looking at will appear. The after-image of green will be purplish-red. The after-image of red will be blue-green, while the after-image of ultramarine blue will be yel-

low. Clear after-images can only be obtained by steady fixation of the gaze under good illumination.

The phenomenon of positive and negative after-images is called "successive contrast," and may be defined as "the apparent alteration of a surface — either colored or colorless, by previous stimulation of the same retinal area." For example, the after-image of the green disc is purplish-red because the nerve endings in the retina that respond to green are temporarily fatigued through gazing steadfastly at that color, and on shifting the gaze to the white disc they are somewhat insensitive and fail to respond to all the light rays reflected from the white surface. Only those sensitive to purplish-red — the complementary of green, function.

After-images manifest themselves according to traceable laws and play an important, though seldom recognized, part in our everyday experiences. They tend to modify all that we see, yet most people go through life without ever discovering the existence of them. However, all who are concerned with color in any manner or form must take cognizance of them and allow for their distortions.

Simultaneous Contrast.—Owing to the influence which neighboring areas of the retina always exert upon one another there occurs in our visual experience a phenomenon closely related to successive contrast. This is called "simultaneous contrast." Because of some process in the visual apparatus, any color that is seen by the eye tends to throw its complementary hue into any color that is placed alongside or superimposed upon it. Study the examples in Fig. 2, on the Frontispiece. Observe how each of the gray spots, which are identically the same in hue and brightness, assumes a different hue in each square. The one on red becomes tinged with bluish-green, the one on ultramarine assumes a yellowish hue, the one on yellow becomes

tinged with ultramarine, and the one on green assumes a reddish hue.

Another example of simultaneous contrast is shown in Fig. 3, on the Frontispiece. Observe the small orange squares super-imposed upon the larger red and ultramarine areas. The orange square on the ultramarine appears much brighter than the one on red. The reason for this is because the ultramarine blue background forces some of its complementary yellow into the orange thereby brightening it, whereas the red throws some of its complementary green into the orange and thus tends to neutralize it and to lower its brightness.

When complementary colors adjoin each other in a color scheme they become intensified because of the influence of simultaneous contrast. Under similar conditions, closely related hues lose much of their brightness because each tends to force some of its complementary into the other.

The artist trusts his knowledge of simultaneous contrast as surely as he trusts the pigments he uses. He employs this knowledge effectively when rendering highlights and shadows. An object receiving bright illumination may present a rather dazzling appearance, and when the artist tries to represent this brilliant play of surface lighting he has to "force" his color. Here is where his knowledge of simultaneous contrast comes in. He realizes that the bright pigments employed for rendering the usual highlights are very inadequate of themselves, therefore, to make such pigments appear more brilliant he contrasts them with deep shades of their complementaries in the immediate shadows.

Brightness Contrast.—A given surface, either colored or colorless, appears brighter or darker than it would otherwise appear according as it is brighter or darker than a neighboring surface. For example, com-

pare the brightness of the two gray figures in Fig. 4, on the Frontispiece. Both are identical in brightness, but, by contrast with their backgrounds, one becomes a light gray and the other a dark gray. This is an illustration of "brightness contrast." The illusion is most marked where the surfaces border each other.

Contrast is both helpful and deceptive. It intensifies differences and thus aids in the distinguishing of objects and surfaces. On the other hand, however, it has the power or tendency to deceive as to hue and brightness unless one is observant and prepared to make proper adjustments and corrections.

Adaptation.—Adaptation of the eye to changing light conditions is another of the peculiarities of color perception. The immediate reaction of the eye to changes in the degree of illumination is a widening or narrowing of the pupil according as to whether the illumination is high or low.

When one first enters a room from a place under greater or lesser illumination, or under illumination of a different quality, the first impression of the changed appearance of the light may be quite different from what it will be after one has been in the room for fifteen or twenty minutes.

Let us see what happens on leaving bright daylight and entering a room illuminated by the light passing through stained glass windows having in their make-up a combination mostly of yellow, orange and red. You will be vividly conscious of an orange-yellow glow. If you open the pages of the book or magazine that you may be carrying, you will observe that they have a soft orange-yellow hue although you are perfectly aware that they are certainly white in ordinary daylight. Gradually, however, this hue will fade away, the "white" pages will establish themselves as white again, and objects all around you will appear as they would in ordinary white light. You have become ac-

customed to the orange-yellow light — adaptation has set in.

In this orange-yellow light, objects that are complementary in color to it are at first neutralized, but by degrees, as the eye adapts itself, these assume their proper hue. If a door should be slightly opened so that a streak of ordinary daylight is seen, this will apparently have a bluish hue. The reason for this will be explained in the next but one paragraph to this.

Another example of adaptation occurs on passing from daylight into a darkened room, hall, or theater. At first, oppressive blackness pervades everywhere. Very soon this effect clears up, and as your eyes become adapted to these conditions the surroundings become more and more distinct. On returning again into the daylight, everything becomes strangely dazzling, but this feeling soon wears off and all things take on a normal appearance.

The immediate after-effect of general adaptation is always opposite, or complementary. For example, if you are adapted to orange-yellow, as when you were in the room illuminated with the predominantly orange-yellow toned stained glass windows, you will become blue-sighted for a short time on returning into ordinary daylight. The reason that the streak of daylight you saw, when the door of the room was slightly opened, appeared quite bluish, was because your eyes were adapted to yellow-orange. Being adapted to yellow-orange produced an overworking and consequent breaking down of the visual organ responsible for this color, and caused a corresponding strengthening or building up of the part of the organ which is opposite to yellow-orange, namely blue. As a result, the streak of daylight appeared over-emphasized in its blue aspect. When red adapted you become blue-green sighted. When dark adapted you

become light sighted, and when light adapted you become dark sighted.

Thus we observe how the eyes play tricks on us. Things do not always appear as we expect them to be. The colors we recognize around us are not exclusively determined by the physical stimulus — light. What we see depends in part upon the original stimulus, upon contrast, and upon adaptation of the eye. Therefore, knowing that colors are active and tend to modify both themselves and their environment, the result of any suggested color scheme or arrangement can be accurately predicted.

Adaptation, as opposed to contrast which is instantaneous as soon as the eyes are opened, requires time. It modifies what would otherwise be irritating experiences, and prevents our being fatigued and disturbed by strong contrasts.

Indirect Vision.—It is an established fact that the color vision of the peripheral retina is very different from that of the center. For example, if you gaze at one particular flower in a multi-colored flower bed, and try without shifting the gaze to observe all the colors at once, it will be noticed that beyond a certain narrow limit the leaves do not appear green, beyond a rather larger limit no red flowers are seen as such although yellow and blue flowers may still be easily identified, and beyond a still further limit all the flowers and leaves look black.

Again, if you shade the left eye and gaze steadily with the right eye at some fixation point placed directly before it or a little to its right, and then from the nasal side slowly move a small red object into the field of vision, the object will first become visible as a patch of black or dark gray. As it advances, it may show slight traces of blue or yellow in the black or gray, and finally, as it nears the fixation point it will show its true red color. All other colors undergo cer-

tain characteristic changes in passing through the visual field.

It has been found by experiment that, normally, white has the full visual field, and that colors have fields which in magnitude are in the order yellow, blue, red and green. There is so much difference in these that the field for green has less than one-fourth the area of the field for yellow.

If, after reducing them to the same brightness and saturation, the true complementaries yellow and ultramarine blue, and red and sea-green, be employed in a similar experiment we would observe that the limits for red and green coincide and those for yellow and blue coincide also. The close coincidence of these two pairs of colors tends to support the theory that the retina contains two pairs of color elements, one for red-green and one for yellow-blue. These four colors are considered by the psychologist as primary, or fundamental, color sensations. They undergo no change when passed through the indirect visual field, and are therefore considered as "stable" colors. Hering calls them "invariables." They are the foundation upon which the psychologist, using the physiological findings regarding the nature and distribution of the color elements, builds his color systems.

Other colors undergo more or less radical changes when passed through the indirect visual field. Generally speaking, the colors in the red zone of the color circle first appear yellowish in the outer regions of the visual field, while those in the blue zone appear bluish. All colors enter the visual field as gray or black. In the yellow-blue field all colors assume some aspect of yellow or blue if they are seen as colors. Reds and greens, and their derivatives, reveal their true colors only within the central region of the visual field.

From these facts we conclude that there are three distinct regions or zones in the retina. The outer zone

is totally color blind and furnishes only sensations of light and dark regardless of the stimulus. The intermediate zone is responsible for sensations of blue and yellow as well as sensations of light and dark. In the central zone all sensations of color and brightness are recorded. The limits of these three zones are not the same in all individuals and may also vary according to particular conditions. The purer the color the larger will be its field. Brightness must also be considered, the brighter the color the larger the field. Area and size are also influencing factors, the larger the area the larger is its field. It has been found by means of certain tests that color fields enlarge with age. The difference in the fields of a young person of nine years of age and one of twenty-two may be very great. Whether this is due to an increased capacity for observation in the latter, rather than an increase of sensitivity in the retinal elements, has as yet not been proved.

Apparently, the reason for the lack of color when objects are far removed to the side of the indirect visual field is that light reflected from them at that point reaches only the extreme periphery of the retina where there are many rods and but few, if any, cones. These observations suggest that the rods are the receptors for achromatic vision only, whereas the cones must be excited for chromatic, or color, vision.

Summing up all this evidence, we find that we are most sensitive to color and form in the direct visual field, that is, when the image falls upon the central region of the retina; and we can detect movement and change in brightness when the stimulus falls upon the outer-lying areas of the retina. The functions of the indirect visual field may be described as of a scout or guardian. By impressions of changing light or movement in the indirect visual field we are made conscious of the presence or approach of an object.

Heeding this signal, the eye quickly turns so as to bring the intruding object into the direct field of vision where it may be accurately observed and analyzed.

Daylight and Twilight Vision.—The sense of vision undergoes much change as we pass from light to dark and from dark to light. When the illumination is maintained above a certain limit we have ordinary daylight vision. We clearly see all colors in every degree of brightness and saturation, as well as all the colorless sensations from black to white. On the other hand, when the illumination falls below a certain limit we have what is called "twilight vision," and we are conscious of gray sensations only, color being entirely lacking.

When the intensity of illumination is so low that objects are barely visible everything seen appears to be black or gray. This is the "threshold of visibility." As the degree of illumination is gradually increased all things appear gray until a certain critical intensity value is reached where objects appear as colored. This point is called the "chromatic threshold" or "color threshold." From the threshold of visibility to the chromatic threshold is known as the "photochromatic interval."

More than 100 years ago, the eminent Austrian physiologist Purkinje observed that striking changes appeared in the brightness relations among various colors when the intensity of illumination was reduced below the threshold for color vision. Colors at the long-wave end of the spectrum were darkened, and those at the short-wave end brightened. In viewing the colored figures in the carpet and the hangings of his study he observed that under daylight conditions the yellow figures were brightest of all, but under deep twilight conditions when all colors appeared as different tones of gray, the brightest gray figures were not those which had appeared yellow in daylight, but

rather those which had been seen as green. Moreover, reds and blues which had appeared of equal brightness in daylight were no longer so. The gray figures which had been blue were much brighter than those which had been red. In deep twilight, red figures became definitely black, while the blues changed to a silvery blue-gray.

The Purkinje phenomenon might be observed by looking at a multi-colored surface through a pinhole in a card, by looking at the colors through nearly closed eyelids, or by taking the colors into a comparatively dark room.

When ordinary daylight is gradually reduced in intensity, as in the fading light of day; yellow will be observed to fade first, then red, next blue, and lastly green. In increasing darkness, the vision is accomplished increasingly by the rods, with a corresponding gradual decrease in cone vision, with the result that the capacity for distinguishing colors is lost sooner than the ability to distinguish light and dark. The comparative lack of color in moonlit landscapes is a consequence of this process.

Physiologists, after much research in the subject of visual perception, have concluded that the rods are the organs responsible for twilight vision, and the cones are sensitive only above the chromatic threshold. The fovea, where cones only are present, is practically blind in dim light.

In this connection, it is significant that the end parts of the rods contain a reddish-purple substance, called "visual purple," which bleaches out on exposure to light, and reforms under the influence of darkness. Scientists, as yet, have not determined with certainty whether the visual purple is essential to rod vision, or whether it serves the purpose of sensitizing the visual apparatus. The rods in the retinas of nocturnal ani-

mals are richly supplied with visual purple, while the cones are entirely deficient of it. The eyes of animals that are strictly diurnal in their habits are lacking in this pigment.

Color Blindness.—We already know how light rays enter the eye, and impinge on the retina, where they encounter the rods and cones which send electro-magnetic impulses along the optic nerve to the brain, thus giving us the sense of sight. However, it does not necessarily follow simply because light waves of a particular length or frequency enter the eye, and are transmitted to the brain, that sensations of color will result. Indeed, there are people who are blind to certain colors. Tests by experts have proved that about eight per cent of all males are color blind, while less than one per cent of all females have this trait.

There are three forms of color blindness, namely (1), red-green blindness, in which the red-green apparatus in the eye is missing or not functioning, (2), yellow-blue blindness, in which the yellow-blue apparatus is missing or not functioning, and (3), total color blindness, in which case only the black-white apparatus remains and functions.

Total color blindness is the most interesting type. People so afflicted are technically termed "monochromats." They see only a world of grays, absolutely devoid of color. The word "monochromatic" is of Greek origin and might be loosely translated into "one-color mechanism." In this type of color blindness only one of the three mechanisms in the retina functions.

Next are the "dichromats." These are the "two-color mechanism" persons. The most common of these confuse the reds and greens, because the red-green apparatus does not function normally. A few dichromats confuse blues and yellows, but these are very rare.

Individuals who have all three color perceiving mechanisms functioning are called "trichromats." Among these, however, are many who have some minor departure from the normal. Such persons are called "anomalous trichromats." They differ from the normal in their slowness to perceive or distinguish certain colors. This weakness is usually in the greens and reds.

Many color blind persons are not aware of their condition, and may never know of it unless they discover it by chance, or through having to take a test in color vision. Color blindness is no serious handicap except in such occupations as call for fine color discrimination.

The Nature of Black.—Among our visual sensations black occupies a very peculiar position. The physicist calls it the absence of light. To the physiologist, black implies the absence of stimulation in the eye. The psychologist believes that the recognition of the absence of stimulation is in itself a positive sensation.

The psychologist believes, as we have already learned, that there are six fundamental visual sensations — red and green, yellow and blue, and black and white. The black and white sensations are absolutely independent of color. That we understand this is very important. Black and white, however, may mingle with color sensations.

Truly, black is negative in light, but in the sphere of visual sensation it is very positive. Visually, black and white behave in the same way as colors. When the organ responsible for a particular visual sensation is excited in one way, recovery from the excitation evokes the opposite, or complementary sensation, thus proving that black and white have a sensory connection the same as red and green, and yellow and blue.

Although physically black is the absence of light, yet, black only occurs just after light has been withdrawn. Immediately after this, the eye adapts itself to the absence of light and the resulting experience is not at all of black but a grayish sensation. Such a sensation is entirely different from that experienced when looking at a black area in normal light. Strange as it may seem, intense black can only be seen in good illumination. A black area in strong light appears blacker than darkness due to the fact that in total darkness the eye nerves are always active, and this action causes the eye to adapt itself to the absence of light, and the experience of filmy, grayish space, is the result.

Black may be observed as an after-image. If you will gaze for about thirty seconds at a white spot on a black background and then shift the gaze to another part of the black background, a spot will appear, the same size and shape as the original one, but will be blacker than the black background.

Film colors — those seen through spectroscopes, and other optical instruments, and which seem to penetrate space, never contain black. Surface colors — those dependent on the physical property of remission from the surfaces of material objects, invariably contain black and may be mixed with black thereby changing their appearance and vastly extending the world of color tones.

An Illusion of Color.—As previously stated, the sensation of vision is not only dependent upon external stimuli, but has its dependence also upon differences of function within the eye and the brain. The eye itself is far more than merely a camera-like receptor for light rays. It has the power to handle external stimuli to suit itself. It may create illusions and distort actual facts. For example, when white and black are made to follow each other at certain speeds an illusion of

color may be produced where no color is present.

If the reader will make a disc about 2¾ inches in diameter, with white and black, as shown on Plate 2, Fig. 4, he will be in a position to demonstrate this for himself. Insert a pin in the center of the disc and spin it at a moderate speed. You will observe a series of colored circles. When spun in one direction the outer circle will appear as dull blue, the second as dull green, the third as dull yellow, and the inner one as dull red. When rotated in the opposite direction, the order of hues is reversed — the outer one is dull red, the second dull yellow, the third green, and the inner one blue. The red appears most intense in ordinary daylight, but when viewed under artificial light it changes to maroon. The speed of rotation must be just rapid enough so that the impressions of the arcs merge in the eye into complete circles. This is called the "Benham disc," after its inventor, E. C. Benham, who published it in 1894.

Re-Discovering Color.—Our everyday sensations of color are greatly influenced by our past experience and knowledge. To all things with which we are familiar we tend to ascribe a certain absolute color, and unconsciously fail to observe subtle differences of hue, brightness, and saturation, because experience has taught us to expect certain effects and results. For example, if one were reading this book under the illumination from red light, it would be hard to resist calling its pages white even though they are undeniably reddened by the peculiar illumination under which they are viewed.

So-called white surfaces are far from being colorless, indeed, a white surface is capable of reflecting any and every color according to the conditions under which it is observed. Snow is usually considered as being white. Looking out of my study window I observe everything covered with a new blanket of snow.

It seems, however, to be very lacking in whiteness. Only those parts that mirror the bright winter sunlight directly are anywhere near to white. For the most part the impression is one of yellowish brightness with blue and blue-violet in the shadows. At eventide, I observe this same snow illuminated by the light of the fast setting sun. It takes on a rosy-pink hue with greenish-blue shadows. As the light fades away I turn on the lamp in my study and again gaze out through the window. The snow now appears quite bluish with richer and darker tones in the depressions. Observe this for yourself the next time the landscape is clothed in a new mantle of snow. You will find that what is considered white snow is very colorful, although rather delicate, in its rendering.

Most persons have never learned to see color analytically. Artists, however, because they are very sensitive to the subtleties of color, see many hues that are hidden from the untrained eye. Because of this, their paintings are oft-times criticized as untrue to nature by those unable to perceive such effects.

CHAPTER FIVE

COLOR, AND COLORANT, MIXTURE

Webster defines color as "A sensation evoked as a response to the stimulation of the eye and its attached nervous mechanisms by radiant energy of certain wave-lengths and intensities." Color to most of us is primarily a matter of sensation, but since there can be no responsive sensation without some kind of stimulus, so there can be no psychological system of color organization and mixture without some sound physical basis.

Color has its source in light. It is the property of light that reaches the eye. Without light there is no color. Pigments, dyes, and inks, however, are not colors in the strict sense of the word, but are colorants. They modify light.

An understanding of the mixture of colors and colorants, with consequent ability to intelligently plot and and plan definite results, should be the goal of every person dealing with color in any manner or form. Through the aid of scientific investigation, methods of charting color and colorant mixture by graphic means have been devised which enable one to correctly foretell all mixtures.

In color and colorant mixture there are three types—additive, medial, and subtractive, which find expression respectively in lights, vision, and pigments.

Light, or additive, color mixtures always work upward, each component adding to the other's brightness. For example, combined red and green lights result in yellow, and the intensity of this yellow is equal to the total energy of red and green.

When pigments are mixed the result is always downward. Each pigment in the mixture absorbs something from the light which falls upon it. The result is a color which has less brightness than any of the components alone, hence the term "subtractive."

Mixing colors visually, as with a revolving disc, is neither additive nor subtractive, but "medial" mixture. Colors so mixed are a compromise between the brightnesses of the colors employed in the mixture.

Additive Mixture.—The physicist has proved that white light is made up of three primary bands of light ray colors. They are red, green, and blue-violet. By a proper mixture of these three colors any colored light may be matched in hue and brightness.

Let us suppose we have a white screen in a darkened room, and that by means of three spotlights we are able to direct on to the screen three lights which correspond in color with the three primary light colors. Three suitable lights, which, when mixed together, would give the maximum gamut in positive light mixture are, 1, a pure red without any trace of yellow, somewhat similar to the standard street traffic signals, 2, a green which contains neither yellow nor blue, and purer than the signal light green, and 3, blue-violet, similar to ultramarine but with decidedly violet hue. By manipulating these lights all possible colored light mixtures may be produced.

Superimposing all three lights results in white light. Green and blue-violet lights superimposed give peacock blue. Red and blue-violet give magenta, while red and intense blue-violet produce purple. When red and green are superimposed the result is yellow, but if an intense red is mixed with a weak green the result is not yellow, but orange. On the other hand, weak red and strong green produce yellow-green. These facts may be tabulated as follows:—

Red	+ green	= yellow
Red (strong)	+ green (weak)	= orange
Red (weak)	+ green (strong)	= yellow-green
Green	+ blue	= peacock blue
Red	+ blue-violet	= magenta
Red (weak)	+ blue-violet (strong)	= purple
Red	+ peacock blue	= white
Green	+ magenta	= white
Blue	+ yellow	= white
Red + green	+ blue-violet	= white

For graphically charting colored light mixture, one of the simplest diagrams is an equilateral triangle, sometimes called the Maxwell Color Triangle. This is shown in Fig. 1, Plate 3. In this diagram the three primary light colors are located at the corners. The colors of the spectrum lie along the two upper sides of the triangle. Those colors that do not occur in the spectrum, namely the purples, lie along the base line which connects blue and red. In order, the colors on this line are blue-violet, purple, magenta, rosepink, and red. All saturated hues are located along the sides of the triangle. A point at the center represents white. As the saturated hues move in towards the center they get gradually weaker and weaker until they become white at the central point, which is called the "complementation point."

Within the boundaries of the triangle, mixtures of all light colors may be plotted. All color mixtures lie in straight lines. If points are placed on this diagram to represent a particular green and a red, and the points connected with a straight line, as in Fig. 2, Plate 3, the line will represent all possible mixtures of these two colors. The exact position on the line GR of a color obtained by mixing green and red depends upon the proportions in which they are mixed. The position of the resulting color divides the line GR into two parts which bear an inverse relation to the

amounts of green and red mixed. For example, if one part of green and three parts of red are mixed, the resulting color lies at a point which is three times as far from green as it is from red. Try out this mixture for yourself with colored lights in the above proportions and you will find the resulting color will be orange. Orange is midway between red and yellow. If you locate a point midway between red and yellow, as in the illustration in Fig. 2, Plate 3, you will observe that its position is three times as far from green as from red.

Now let us plot points to represent yellow and blue-violet in the diagram, as in Fig. 2, Plate 3, and connect them with a straight line. On this line all colors resulting from the mixture of these colors will be represented. Travelling from the yellow point, the yellow gets paler and paler until it assumes white at the complementation point. Continuing along the line, the white takes on a faint bluish tinge which gradually increases in saturation until the point is reached where blue-violet is located. Superimposing yellow and blue-violet lights on a screen results in white light. By varying the proportion of each color to the other, all colors represented on the line BY may be produced.

When colored lights are mixed they add to each other's brightness, therefore, there is a gain of light. For this reason the mixing of colored lights is called "additive" mixture.

A graph much used in additive color mixture is the one adopted in 1931 by the International Commission on Illumination, and known as the I. C. I. system. It is shown in Fig. 3, Plate 3. In it the visible spectrum is arranged in almost triangular fashion, with very purplish blue at 400 millimicrons in wave-length at one end, and passing through blue, green, yellow and orange, to red at 700 millimicrons in wave length. A millimicron is equal to one-billionth of a meter, or,

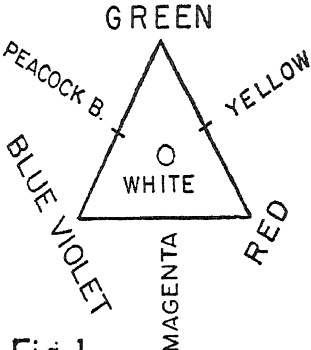


Fig. 1

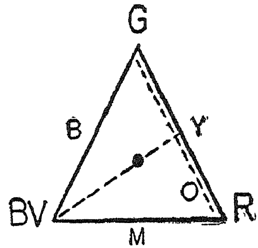
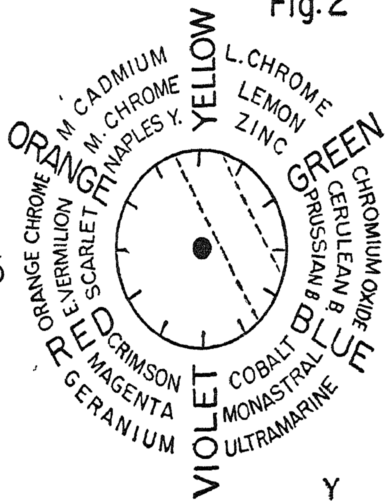


Fig. 2

Fig. 5



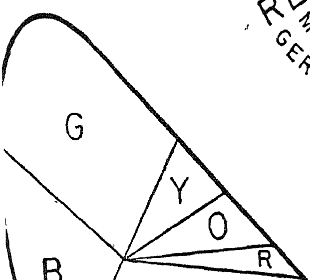


Fig. 3

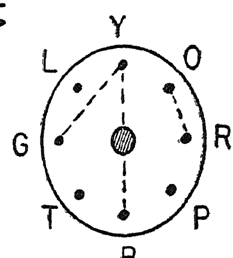


Fig. 4

PLATE 3

which is the same, one millionth of a millimeter. The colors that do not occur in the visible spectrum — the purples, are enclosed by a straight line connecting the purplish-blue and red.

All colors and their mixtures may be plotted in the I. C. I. color mixture diagram in the same way as in the Maxwell Color Triangle.

Medial Mixture.—Mixing colors visually by means of revolving discs is "medial" mixture. When red and yellow are mixed in varying proportions on a revolving disc all tones of orange may be produced. By similarly mixing blue and red the purples and violets are produced; by mixing blue and green, all the bluish greens; and, by mixing yellow and green, all the yellowish greens. However, when the complementaries blue and yellow are so mixed, the result is neutral gray. The same result occurs when the complementaries red (purplish) and green (sea-green) are mixed. Complementaries, when mixed on the revolving disc, always give neutral gray.

Other cases of medial color mixture are 1, when different colored threads are woven or interlaced together, 2, when fine lines, dots, etc. of one color are distributed over a ground of another color, and 3, when opaque, colored powders are mixed. In each case their mixture produces the same results as when colors are mixed on the revolving disc.

Fig. 4, Plate 3, shows an arrangement of the eight principal hues of the psychological color circle. In the center is neutral mid-gray. All hues, produced by mixing on the revolving disc different proportions of any two colors, lie on a straight line joining the colors concerned. For example, the hues that result from the mixture of varying proportions of yellow and green lie on the line YG. They will vary from yellow through leaf to green according to their position on the line. Colors mixed in this manner lose very little

of their original brightness because the saturated hues are at middle brightness the same as the mid-gray at the center. However, their saturation or purity is affected and depends upon how far the resulting mixtures are from the circumference of the circle. The point located at the middle of the line YG represents a mixture of equal amounts of yellow and green. It is the least pure color resulting when these two colors are medially mixed because it is the nearest point to the mid-gray center and so contains most gray.

Now suppose we mix red and orange. The resulting colors will lie on the line RO, and because none of them are far removed from the circumference of the circle they are almost pure. On the other hand, when yellow and blue are mixed in varying proportions some of the colors obtained are very close to the mid-gray center, and one of them, namely that resulting from mixing equal parts of yellow and blue, actually lies at the center of the circle and therefore must be neutral mid-gray. Yellow and blue are complementary colors and when complementaries are medially mixed in proper amounts the result is always neutral mid-gray.

Mixing colors visually, as on the revolving disc, is classed by many scientists as "additive." They liken such mixture to the blending of colored lights. This is erroneous. For example, red and green blended on a revolving disc will never result in yellow as would the mixing of red and green lights.

Colors mixed on the revolving disc although they may not lose any of their individual brightness, are always less saturated than the original components due to the introduction of black which surface colors always contain.

To emphasize the fact that the visual mixture of colors is quite apart from the mixture of colored lights let us consider the following rudimentary illustration. Suppose a beam of red light having a quality of, let

us say 100, is thrown upon a white surface, and a beam of green light with a 100 quality is superimposed upon it, the result will unquestionably add up in quality to 200 because the result is the combined energy of the two. But, in order to combine red and green discs on the revolving disc, the area of one must be reduced to make room for the other. Hence the two combined can never equal more than 100 nor reflect into the eye more than 100 quality.

Subtractive Mixture.—When mixing pigments, dyes, printing inks, and other similar materials, their characteristic hues must be taken into consideration. For example, some blues such as ultramarine and cobalt have a reddish hue, while blues, such as cerulean and Prussian, have a decidedly greenish hue. Again, there are reds, such as scarlet and English vermilion, that have a yellowish hue, and others, such as rose lake and crimson, that have a bluish hue.

For diagramatically plotting colorant mixture a most practical chart is the twelve-hued circle of the Brewster theory, an interpretation of which is shown in Fig. 3, Plate 2, and explained in Chapter three. Adapting this color circle for the purpose of showing the results of colorant mixture, points have been fixed to represent the six spectral hues, as in Fig. 5, Plate 3. These will be identified as pure yellow, pure green, pure blue, pure violet, pure red, and pure orange. At the center is the complementation point. It is neither white nor mid-gray, as in additive and medial mixtures, but a muddy, blackish gray. Colors directly opposite each other in this color circle are said to be complementary, and they always give a muddy gray when mixed together. Between the six pure spectral colors we have located certain pigment colors. For example, scarlet has been placed between pure red and pure orange because it is a red with a yellowish hue, whereas crimson is placed between pure red and pure

violet because it has a bluish hue. Again, cerulean blue is placed between pure blue and pure green because it has a greenish hue, but ultramarine blue is located between pure blue and pure violet because of its characteristic purplish hue.

All color mixtures lie in straight lines. To produce mixtures that are relatively pure, colors inclining towards each other should be mixed. Suppose it is desired to mix a bright green with yellow and blue pigments. The choice of components would be a greenish blue, such as Prussian or cerulean, with a greenish yellow, such as either light chrome or lemon yellow. If a reddish-hued blue such as ultramarine together with a reddish-hued yellow such as medium chrome were mixed together the resulting green would be very low in brightness. This may be proved by means of the diagram in Fig. 5, Plate 3. Two dotted lines will be observed in the region of green, one of which connects a greenish yellow with a greenish blue. On this line all colors resulting from the mixture of varying amounts of these colors are located. The line is far removed from the central blackish gray and is therefore comparatively pure. The other line, connecting reddish yellow with reddish blue, is in parts very near to the center and shows that the green resulting from this mixture is dark and much neutralized. When mixing colored pigments, the point to remember is that when those pigments that incline towards each other are mixed, the resulting colors are relatively bright, and when either of the components of a mixture has an opposite hue to the desired color, the result will be a color low in brightness.

Blue and Yellow in Color and Colorant Mixture. — The question is often asked, "Why is it that when all the colors of the solar spectrum are properly mixed the result is white light, but when colored pigments which match as nearly as possible these same colors

are mixed the result is a blackish neutral instead of white?" The reason for this is that when colored lights are mixed each adds its own brightness to the result thereby making a combination that is brighter than any of its components because it is the sum of the energies of each. When all the colors of the spectrum are properly mixed, the sum of their brightness exceeds that of any individual brightness, and the result is white light which is brighter than any of the colors which compose it. On the other hand, when pigments are mixed, each one absorbs some part of the light which falls upon it, and we see only that which has not been absorbed. In pigment mixture there is a subtraction of rays from the light which they receive, and the result in most cases is either darker, or duller, or both, than either of the components — hence the term "subtractive." When colored pigments which match as nearly as possible the spectral hues are all mixed together and painted on a surface, each pigment absorbs some portion of the light which falls upon it, and only a blackish neutral gray escapes to be reflected to the eye. The combined absorption of the various pigments takes so much from the light that very little of the original brightness of any of them is left.

Another question which comes to mind at this time concerns the variety of results obtained when blue and yellow are mixed. Why is it that when blue and yellow lights are mixed the result is white, and when blue and yellow discs are revolved the result is gray, but when blue and yellow pigments are mixed the result is neither white nor gray, but GREEN? Blue and yellow lights are complementary and for this reason their mixture produces white. Blue and yellow are also complementary when mixed on revolving discs, and the result of their mixture is a neutral mid-gray. However, blue and yellow pigments are not comple-

mentary and for this reason their mixture produces a color somewhere between them. When these two pigments are mixed the resulting mixture still consists of fine particles of blue and yellow, and each particle, because of its power of absorption, subtracts a particular part of the light and reflects the rest. White light is made up of red, orange, yellow, green, blue, and violet. From this combination the blue pigment absorbs practically all the orange and most of the red and yellow. The yellow pigment absorbs almost all the violet, the remainder of the red, and nearly all the blue. Green is the only color which neither absorbs. This is reflected, and the result appears as green.

White light is made up of	R	O	Y	G	B	V
Blue pigment absorbs	R	O	Y			
Yellow pigment absorbs					B	V
That which is left is				G		

The mixture of pigments gives only the color which neither absorbs, and not the sum of the colors as is obtained when colored lights are mixed or added together.

Looking towards the sky, or some other source of "white" light, through two differently colored pieces of glass placed in contiguity is another example of subtractive color mixture. The light which passes through each glass is deprived of some of the light rays peculiar to that piece of glass and only the rays that are left reach the eye. If a piece of blue glass is held between the eye and a suitable source of illumination and then covered with a piece of yellow glass in such a way that the light has to pass through both pieces before reaching the eye, the resulting color would be green having rather less brightness than either the blue or yellow pieces of glass. From the original white light, the blue glass absorbs practically

all the orange and almost all the red and yellow, and allows blue, green, and violet to pass through. The yellow glass, in turn, absorbs practically all the violet, nearly all the blue, and the remainder of the red. The only color which neither of the pieces of glass absorbs is green, which passes through to the eye.

Similarly placed red and yellow glass plates would give an orange having somewhat less brightness than either the red or the yellow. Blue, yellow, and red pieces of glass when similarly placed give black, because all light is absorbed.

Mixing and Matching Colorants.—The most satisfactory way to study pigment mixture is to actually make mixtures for yourself. How successful you are will depend upon how much effort you put forth. There are many factors which need due consideration, such as characteristic hue, tinctorial strength, permanency, etc. . . . A pigment in the thick paste form as it comes in the can or tube gives only a little of its qualities. To note its true hue spread a little of it out thin on a white surface, using the thumb or a palette knife. To learn something of its tinting quality mix it with white pigment. When making a study of tinting colors always use the same amount of white; for example, take one ounce of white as the standard. Then take a measured amount of the tinting color, say one quarter ounce, and mix it with the white. By following this standard you will learn which are the strong tinters and which are the weak.

The first experiments in acquiring a knowledge of the tinting characteristics of pigments might be to take several reds, blues, yellows, greens, browns and blacks, and mix them with white. You will observe that Venetian red when used to tint white will show a suggestion of yellow. Indian red will show a rather grayish purple hue, while Tuscan red will reveal a hue leaning towards lavender. Cobalt blue and ultra-

marine will show more gray in tints than will Prussian blue. Rose pink, when mixed with white, will be grayer than rose lake. Now considering the umbers and siennas, a raw Italian sienna used to tint white will show yellow with a suggestion of green; burnt Italian sienna will give a red-tan suggestion; raw Turkey umber a gray with a decided green cast; burnt Turkey umber a warm off-gray with a suggestion of yellow and red. Vandyke brown will develop into a purple gray. When lampblack is mixed with white the result is a bluish gray, but when vegetable black, ivory black, or drop black are used, the resulting gray is quite brownish.

Compare a number of reds and you will find that one is bright while another is dull, one is yellowish while another is bluish, one is very opaque and another is rather transparent. Making similar comparisons with other colors will reveal many peculiar characteristics.

There are usually two or more ways to mix any color. The best way to mix it for one purpose is not necessarily the best for another. Only by study and experimentation is it possible to learn color characteristics so well that one is able to produce any given color for its particular purpose. Expert color mixers are to be judged by the number of different color tones they can produce with the least number of colors in the combination. Whenever possible use a green base for green tints rather than a mixture of yellow and blue. Use a violet or purple base for orchid and wisteria tones instead of a combination of red and blue. In this way, surprisingly satisfactory results may be obtained over and above the careless and promiscuous intermixing of anything that appears fairly suitable.

The kind of light which is most satisfactory for mixing and matching colors is bright daylight. Avoid both direct and reflected sunlight, especially when the

reflection comes from a neighboring colored surface. As a rule, a steady north light on a bright day is the ideal condition. Diffused, color-corrected artificial light which simulates daylight as closely as possible is very good.

Gazing steadily at a color for a time while mixing tires the eyes causing them to lose their ability to correctly judge the nature of the color. The reason for this is explained in Chapter Four. It is a good plan therefore, to rest the eyes often when mixing or matching colors. Go away from the work occasionally and look at something different. In this way the eyes will regain their normal sensitivity.

It is a rather difficult matter to make a liquid paint match a dry sample color. The best procedure is to spread a little of the wet paint on to a surface and then defer decision until the paint is dry.

Matching a liquid paint to a liquid paint sample is comparatively easy. By spreading a little of the sample on to a white surface one can judge pretty well what colors were used in its composition. Mix portions of each of these colors together and make periodic comparisons with the sample. To test for perfect match, spread a little of each paint on to a surface so they adjoin and where the two come together it will be easy to judge whether the match is correct or not.

Most paints change in color when they dry. Flat paints usually dry lighter and gloss paints darken. These characteristics should be taken into consideration when matching a flat paint to a gloss sample or a gloss paint to a flat sample.

If the problem is to match colored fabrics like drapes, mottled colors in rugs, wallpapers, or such like surfaces the best that can be done is to approximate the general color tone and not try to match any particular color. Textured surfaces are difficult to match in color

due to the play of highlights and shadows. These can only be approximated.

In very exacting color work the color advisory service department of a large paint manufacturing concern had the walls painted neutral gray so that surrounding areas of color would have a minimum of influence upon the colors being matched. The operator's clothing was covered with a neutral gray apron or coat so that even such remote influences as a bright necktie or shirt would cast no color reflection upon the working surface to influence the eye or impair the accuracy of the color matching.

Arrangements were made so that it was possible to view the colors from one standard angle at one standard distance. This eliminated the possibility of deviation from absolute accuracy caused by variations in eye angle or eye distance. An angle of 45 degrees was found satisfactory for the rack holding the colors for comparison and the distance at which the colors should be viewed was set at 20 inches.

Color-corrected light of a quality that most exactly simulated ideal daylight conditions was employed. This did much to standardize the light intensity and color accuracy. Diffusing the light at its source made possible, to a marked degree, the avoidance of highlights that sometimes develop to distort colors being matched.

By maintaining uniformity in these conditions, results were greatly improved and exactness in producing colors years hence was assured.

CHAPTER SIX

COLOR PERMANENCE

Accurate knowledge concerning the permanence of pigments, inks and dyes, rather than "hit-or-miss" conjectures, is an important and vital necessity in the field of application of these colorants. It is quite generally recognized that some are permanent, some fairly permanent, some of relatively poor permanence, and others quite fugitive.

Every person manipulating colorants, regardless of the purpose or use, is confronted with the problem of permanence. He may use the finest products that the market will afford only to realize eventually that those pigments which he supposed were permanent have faded.

Usually the one who applied them is blamed for the faded condition. Often the responsibility is properly placed, because so few have taken the trouble, or perhaps have not had the opportunity, to learn the fundamental principles of the chemical action or changes that take place when certain pigments are mixed, and which might cause what were considered permanent pigments to fade. Regardless of the permanence of any colorant of itself, its improper association with others may cause fading.

There are many factors that must be taken into consideration before any predications can be made as to the relative permanence of a pigment, ink or dye. The most important and significant of these factors are: (1) The actinic value of the light to which the colorant is exposed. (2) The characteristics of the vehicle portion of the mixture and the type of film formed on

drying. (3) The relative humidity and chemical activity of the atmosphere to which the colorant is exposed. (4) The degree of dilution of the colored pigments by either opaque white or colorless extenders. (5) The chemical reaction of some pigments in combination. (6) The amount of handling received. (7) Susceptibility to fungous growth.

Color Changes Caused By Actinic Light. — Very many cases of fading and changing of colors are attributed to the ultra-violet rays in light, as these rays are known to be the most active from the chemical point of view. They produce, or effect, chemical changes due to their radiant energy, and for this reason are known as "actinic," or chemical, rays. One type of fading and color change is produced by the light waves causing direct photo-chemical reactions, or re-arrangements of the molecules, in the colored pigments. Another type is caused by indirect effects in which the light waves produce reactions which in turn cause fading. This type of reaction may occur in several ways. Ozone, peroxides, or other oxidizing compounds may be formed by the action of the light, or moisture, or both, and they in turn may affect the color. Again, a colored pigment may be rendered light-sensitive by the effect of light on one of the other constituents of the mixture.

Light sources, their intensity, and also the atmosphere to which the pigments are exposed are influencing factors in the evaluation of light sensitivity. Light, even diffused sunlight from a northern sky, varies greatly. The relative proportions of the various wave-lengths in the light, from the ultra-violet to the infra-red, will vary in sunlight with the location of the exposure, the season of the year, the time of day, and the condition of the atmosphere. Since the sensitivity of a colorant to light of different wave-lengths is not uniform, the degree of fading of a specific colored pig-

ment, or the relative fading of a series of colored pigments, may vary considerably with variations in the light.

Character of Vehicle As Affecting Permanence. — The vehicle in which a pigment is ground has a decided bearing on the permanence of the resulting paint, ink, etc. For example, certain vehicles have a tendency to yellow with age thus causing discoloration which is most noticeable in light tones. Some vehicles exhibit a marked tendency to turn white, or "chalk," on exposure to moist air and hence give a false impression of fading. Such vehicles are usually based on untreated rosin. The original color can generally be restored by rubbing off the chalky layer, or coating the surface with varnish or drying oil. Certain glossy vehicles protect the pigments incorporated in them and therefore improve their permanence.

Effect of Atmospheric Humidity and Gases. — The humidity of the atmosphere in which pigments are exposed is known to have a marked bearing on permanence. Generally, the higher the relative humidity of the atmosphere the more rapid is the fading of the color. In the presence of moisture, either in the atmosphere or on the surface to which the pigment has been applied, free lime accumulations will fade out a color and saponify the vehicle thus causing dull faded spots to appear.

Another factor that is known to affect permanence is the chemical activity of the atmosphere in which the pigments are exposed. Sulphur fumes will cause lead chromates such as canary yellow, lemon, light, medium and orange chrome yellows, to darken. Chrome green will also darken when exposed to these fumes, as will American vermilion.

Gases from stagnant water and sewers, which contain hydrogen sulphide, have a darkening effect on some paints, resulting in an unpleasant smudgy ap-

pearance which may exhibit an irridescent effect resembling the metallic luster of graphite. A simple test to determine whether hydrogen sulphide is causing such discoloration consists of applying a few drops of peroxide of hydrogen to the discolored surface. If this liquid, without any rubbing, restores the paint to its original color, the trouble is due to hydrogen sulphide fumes.

An example of discoloration to painted surfaces caused by hydrogen sulphide gases occurred some time ago in the city of Philadelphia and its environs. Raw sewage was allowed to flow into the Delaware River, and due to the river's sluggish flow during summer droughts a large amount of decaying matter was deposited along its banks. Later on, when the heavy rains came, the river and backwashes were stirred up. A chemical action thén occurred, through which large quantities of hydrogen sulphide were discharged into the air, causing paint discoloration which was especially noticeable along the banks of the river where buildings stood.

Concentration of industrial gases and fumes in the air, extremes in humidity, ocean salt air breezes, all influence pigments to some degree and only the best can withstand this atmospheric bombardment without appreciable fading.

Effect of Pigment Dilution By Extenders, — Etc. On Permanence. — It is a well known fact that the permanence of many pigments is seriously impaired by dilution with either opaque white pigments or colorless extenders, such as barytes and silica. The permanence generally decreases rapidly as the dilution increases. When deciding as to the permanence of colored pigments the dilution in which they are to be used should be taken into consideration. As an example, a strong blue tint of a phosphotungstic blue toner, as might be produced by four parts of a white

pigment to one part of toner, will possess much better permanence than a tint produced from forty parts of white to one part of toner.

Tinctorial strength is an important factor in colored pigments. To illustrate, Prussian blue is available that is labeled "C. P. Prussian Blue," and also simply "Prussian Blue." This fact is also true of other colors as, for example, chrome yellow, chrome green and chromium oxide of green — all chemically made pigments. The difference between pigments marked "C. P." and those not so marked is in cost and tinctorial strength.

A study of two typical formulas, one for "C. P. Prussian Blue" and the other for ordinary commercial grade Prussian Blue, will make the above-mentioned facts clear.

C. P. Prussian Blue:
  Pigment 48%, Vehicle 52%.
  Pigment composition:—Prussian Blue 100%.
  Vehicle composition:—linseed oil 83%, turpentine 17%.

Prussian Blue:
  Pigment 59%, Vehicle 41%.
  Pigment composition:—Prussian blue 51%.
    barium sulphate 29%.
    aluminum silicate 15%.
    aluminum hydrate 5%.
  Vehicle composition:— linseed oil 82%.
    turpentine 18%.

The interesting point in these two formulas is in the fact that in the "C.P." formula there is 100 per cent of Prussian blue. In the other formula there is only 51 per cent of the 59 per cent of pigment content, which amounts to 30.09 per cent, of Prussian blue. The other materials have no tinting strength but are there as a base or bulking factor. All things being equal, the pigment having 100 per cent of Prus-

sian blue is certainly bound to be more permanent than one having only 30.09 per cent of Prussian blue in it.

Tinctorial strength is the first measure of value in any colored pigment. Mixing one-quarter ounce each of two brands of colored pigments with a half pound of white for each will indicate which of the two has the highest tinctorial strength. Spreading colors thinly on glass and holding them up to the light reveals color tone, brightness and clearness characteristics.

Although reputable manufacturers always try to put out the best materials, yet, it is possible that the color elements used by one in the production of a certain color might be destructive to the color elements employed by another. For this reason, in striving for highest color permanence, best results in colored pigment mixture are to be had by using as the coloring mediums the products of one manufacturer.

When a paint into which has been incorporated a relatively large amount of extender is exposed, there is a marked change in the course of time in the refractive index relationship between the extender and the disintegrating vehicle, with the result that the paint gradually assumes a faded or "chalky" appearance. However, if such a surface is coated over with varnish or drying oil, the color will be restored.

Thickness of film, after application of a pigment to a surface, also affects permanence, it being well known that a thicker film within certain limits, is more permanent than a thin one, especially if the thick film is built up by a series of thin applications.

Effect of Chemical Reaction on Permanence.—When certain colored pigments are combined, unfavorable chemical reactions occur. One such instance is when ultramarine blue, French blue, new blue, or permanent blue are mixed with white lead, flake white and colors derived from lead. Sulphur enters into the making of

these blue pigments, and this causes a chemical reaction with lead which results in a darkening of the mixture. When making tones in which these blues must be combined with white, use zinc oxide instead of white lead. Practically all blue pigments, other than these combine satisfactorily with white lead.

Ultramarine and cobalt blues are proof against active lime, soda ash, and alkali in new cement and plaster, and because of this, hues made with these blues do not fade and spot under these conditions as do tones made from Prussian blue.

Prussian blue, Paris blue, mineral blue, Antwerp blue, and Chinese blue are cyanide of iron compounds. They have the tendency to turn themselves and other colors with which they are mixed, greenish.

English, French, and Chinese vermilions are compounds of mercury and sulphur. They should not be combined with white lead or lead chromates such as chrome yellow, orange chrome, or American vermilion because lead causes them to turn blackish. Neither should they be mixed with colors derived from copper, such as emerald green, Paris green and malachite green, as such mixtures form unfavorable chemical reactions with result in color fading.

American vermilion is a basic lead chromate, and may therefore be satisfactorily mixed with white lead and other lead based colors. It should not be mixed with pigments derived from sulphur because such mixtures cause the American vermilion to darken.

Cadmium yellow, because it is derived from sulphur, reacts unfavorably with lead chromates and pigments derived from copper.

Fading Due to Handling.—In ordinary handling, printed material may be spotted, smeared, or otherwise blemished by acetic acid deposited by perspiring hands. The person responsible may not be aware that such deposits are being made, but jewelers who deal

in fine plated ware, and vendors of fine silks and satins, etc., for the fair sex, know the destructive possibilities of impressions made by the fluid which exudes from the finger tips in greater or lesser degrees.

Much printed matter, such as exterior posters on billboards, never comes in contact with hands after it is in place, but such things as colored bookplates — especially those used in childrens' books, greeting cards, and colorful party favors receive more or less handling when in service and are subject to the effects of contact with perspiring finger tips.

Perspiration contains small amounts of uric acid, and when this is deposited by the fingers on to a printed surface it tends to deteriorate any color with which it comes in contact.

All printing inks are not perspiration proof. It is possible, however, for the printer to ascertain whether or not certain colored inks can stand up under its action. When perspiration is first deposited it is in an acid state. Later it becomes alkalin through decomposition. There are two tests in general use to determine the fastness of a color to the action of perspiration, one to be used when the perspiration is fresh and one for use when the perspiration has reached the decomposed stage.

(1) For fresh perspiration: Ten grams sodium chloride, one gram lactic acid, one gram monsodium orthophosphate to a liter of solution.

(2) For decomposed perspiration: Ten grams sodium chloride, four grams ammonium carbonate, one gram disodium orthophosphate to a liter of solution.

Discoloration Due to Mould, Mildew, or Fungous Growth.—Under certain conditions, an agency invisible to the human eye is constantly reducing the color value of inks, dyes, stains, pigments, and practically all materials applied to paper, fabrics, wood, and other

surfaces. This agency, which is distinguishable by the use of a strong magnifying lens, is a color-deteriorating micro-organism which thrives in high temperatures as well as cold, in damp conditions, in insanitary places, and in localities and situations where the atmospheric humidity is or has been persistently high, causing a fungous growth which is called mould or mildew. Such attack rarely results in a uniform discoloration of the whole surface but is patchy or blotchy, and may be blackish, greenish, or grayish in nature. Sometimes a superficial powdery growth is visibile on the affected area.

Often when colored printed matter is packed in boxes mildew will form and color failure will be noticed. It is more distinct toward the sides and edges than in the center. Enclosed air spaces at the ends of packages, crevices, knots in strings used for tying, etc., are places where fungous growth can be the most luxuriant imaginable.

The addition of an antiseptic or fungicide, having sufficient destructive power to eliminate the growths without affecting the coloring substances in the inks, and compliance with sanitary rules will do much to ensure printed matter being delivered to a customer before a colony of fungus forming micro-organisms becomes established.

In some instances, as in greenhouses and badly ventilated damp interiors, the presence of mildew is accompanied by a sour odor which can readily be recognized. As the micro-organisms develop in great numbers quickly, so they die, and it is supposed that the sour odor comes from the decomposed bodies.

To treat a painted surface which is spotted with mildew, it should be thoroughly washed with a solution containing tri-sodium phosphate or sodium melaphosphate at the rate of about one pound of the salt to a gallon of water, and thoroughly rinsed afterwards

with clean water. The affected area should then be carefully sponged over with an antiseptic solution. A suitable solution is one part of mercuric chloride to 500 parts of water. Where poisonous conditions must be avoided, one part of thymol dissolved in 200 parts of alcohol is excellent.

Where conditions are exceptionally favorable to fungous growth, the addition of a suitable fungicide or antiseptic is required to ensure the paint remaining free from discoloration resulting from such conditions. The addition of 2 per cent of mercuric oxide to a colored paint, or 2 per cent of corrosive sublimate to a white paint has been found very effective in many cases.

In a United States patent by Wetcher for the preparation of a non-poisonous germicidal paint an interesting claim is put forward. The paint consists of a varnish vehicle with a phenol aldehyde resin and thinners containing an acetal such as ethylal, which functions as a generator of formaldehyde as a result of the oxidation hydrolysis processes which take place during the maturing of the paint film. The liberated formaldehyde is said to ensure immunity from the action of fungi.

Classification According to Average Permanence. — Pigments are of two types — organic and inorganic. Organic pigments are compounds of carbon, hydrogen, oxygen, nitrogen, and occasionally sulphur. Many are derived from coal tar, and they include such colors as lithol red, para red, toluidine red, and solfast blue. Inorganic pigments are metallic and mineral compounds, and include such common pigments as chrome yellow, chrome green, iron blue, the ochers, and umbers.

In the following tables some important pigments are analyzed and classified according to their permanence under average conditions:—

ORGANIC PIGMENTS

	Light resistance		Chemical Resistance	
	Saturated	Diluted	Alkali	Acid
Indanthrene Maroon	Excellent	Excellent	Good	Good
Alizarine Maroons	Exc.	Exc.	Good	Good
Lithol Rubine	Good	Fair	Good	Good
Pare Red	Good	Poor	Good	Good
Toluidine Red	Exc.	Fair	Good	Good
Rhodamine Red	Good	Good	Fair	Good
Permanent Orange	Exc.	Poor	Good	Good
Permosa Yellows	Exc.	Good	Good	Good
Solfast Green	Exc.	Exc.	Good	Good
Solfast Blue	Exc.	Exc.	Good	Good
Indanthrene Blue	Exc.	Exc.	Good	Good
Phosphotungstic Blue	Good	Fair	Fair	Good
Permanent Methyl Violet	Good	Fair	Good	Good

INORGANIC PIGMENTS

	Light resistance		Chemical Resistance	
	Saturated	Diluted	Alkali	Acid
Cadmium Red	Excellent	Excellent	Exc.	Poor
English Vermilion	Fair	Fair	Exc.	Fair
American Vermilion	Exc.	Exc.	Fair	Poor
Indian Red	Exc.	Exc.	Exc.	Fair
Umbers	Exc.	Exc.	Fair	Poor
Chrome Yellow Orange	Exc.	Exc.	Fair	Poor
Red Lead	Exc.	Exc.	Exc.	Poor
Ochers	Exc.	Good	Good	Poor
Iron Yellow	Exc.	Good	Good	Poor
Chrome Yellow, Light	Fair	Poor	Poor	Good
Chrome Yellow, Medium	Good	Fair	Fair	Good
Cadmium Yellow, Light	Exc.	Exc.	Good	Poor
Cadmium Yellow, Med.	Exc.	Exc.	Good	Poor
Zinc Yellow	Good	Good	Poor	Poor
Chrome Green	Good	Fair	Poor	Good
Chrom. Oxide of Green	Exc.	Exc.	Exc.	Exc.
Iron Blue	Good	Poor	Poor	Good
Ultramarine	Fair	Fair	Good	Poor
Cobalt Violet	Exc.	Exc.	Exc.	Good
Mineral Violet	Exc.	Exc.	Exc.	Fair

Any practical classification of pigments with respect to permanence must naturally take into account their respective uses. For example, the classification of pig-

ments for use in paint might be entirely different from that of pigments made into printing inks due to the great differences in the relative thicknesses of the films applied, and the ratios of the pigment to vehicle in the two products.

The subject of permanence opens up a broad field for investigation. Since the degree of permanence varies with the colored pigment used, its purpose, the amount of dilution and the nature of the diluting agent, the vehicle into which it is incorporated, its chemical reaction when mixed with other pigments, etc., the consequences of such an investigation are almost limitless.

CHAPTER SEVEN

COLOR STANDARDIZATION SYSTEM

In most fields of endeavor there exist standards and definitions that are almost universally intelligible. Color, for some reason or other, seems to have lagged behind other sciences in this respect. At the present time, when color plays such an important part in industry and education, there is indeed a great need for efficient color standards. Many efforts have been made by scientists and investigators into the phenomenon of color to develop systems and devices which would make possible the perfect description of any color so that it may be easily duplicated without the need for an actual sample.

There are three factors to be considered in the effort to organize color: 1, the colorant, which modifies or alters light by remission or reflection; 2, light, which may or may not be altered; 3, color sensation, which results from the action of light waves upon the retina. There has been much written about the physical aspect of color in which the first consideration is light, its constituents and their admixture. Artists of the old school have made use of charts and systems of colored pigment mixture. Observant artists discovered how patterns of intermingled colors often gave completely different sensations than would complete mixtures of the same colors. That the mixture of blue and yellow pigments produces green was undisputed, but, when the same pigments were mingled in the form of small dots or alternate lines of each color, something different occurred. Instead of green, the result was a neutral gray. Many began to reason whether it was more important to arrange colors according to light

mixture, or to pigment mixture, or to the results obtained through pattern and the resulting sensations.

Men then began to delve seriously into the possibilities for methodical analysis, identification and measurement of color. Newton is credited with designing the first of all color circles. Later, LeBlond (in Germany) and Gautier (in France) independently discovered that red, yellow and blue had the characteristics of being able to form other colors when combined. Brewster based his works on this idea.

Other color circles were later designed. Those who studied light mixture used three principal colors — red, green and blue-violet. Red, yellow, green and blue were championed as principal colors to comply with the observations made by psychologists.

Color circles, however, were merely incidental in the problem of color organization. What was needed was some system whereby the world of color could be organized in a three-dimensional figure which would dramatically represent not only pure hues but all possible modifications toward white, black and gray.

What seems to be the earliest attempt at color organization was made in 1689 by Waller. It took a form much like a checker board with pure hues along the outer edges and mixtures moving toward the center. Later, in 1745, Mayer used a series of triangles. Lambert, in 1774, also thought in a series of triangles. The base triangle contained pure colors and their mixtures. Other triangles were added above this, becoming progressively smaller as they approached white.

In 1810, Runge made a most intelligent contribution by designing a sphere, with pure hues at the equator, and with white and black at opposite poles. Chevreul, in 1835 designed a hemisphere, which was not only impractical but a step back rather than forward. In 1876,

Von Benzold designed a cone with pure hues at the base and black at the apex.

In 1879, Ogden Rood designed a most progressive and ideal figure in the form of a double-cone, with pure hues at the circumference or equator, white at the apex or north pole, and black at the opposite end or south pole.

Man began later to conceive of his sensations of color as something entirely apart from light and colorants. Color sensation and the visual relationship of colors became very intriguing subjects. The study and exploration into this realm of color brought forth new systems of color order and measurement based on everyday color experiences.

There are in common use at the present time several very ingenious systems in which colors have been standardized and fixed by forms of physical measurement so that it is possible, by merely stating certain letters and numerals, to give an exact description of any color. The vague terms so common in everyday usage have been replaced with an accurate and practical nomenclature. By means of the systems and devices it is now possible for colors to be transmitted by telegraph or cable to any place within a matter of minutes. Of these, three are outstanding. They are the Munsell, Ostwald, and Birren systems. Not one of them disputes the importance of other systems based on colored light mixture, and on the mixture of pigments, dyes, inks and so forth, but all three insist upon the study of color as sensation. They base their systems of color measurement and standardization on the orderly arrangement of the visual attributes of color independent of light or colorants.

THE MUNSELL SYSTEM

A very outstanding figure in the field of color standardization was Albert Munsell. Born in Boston, Mass-

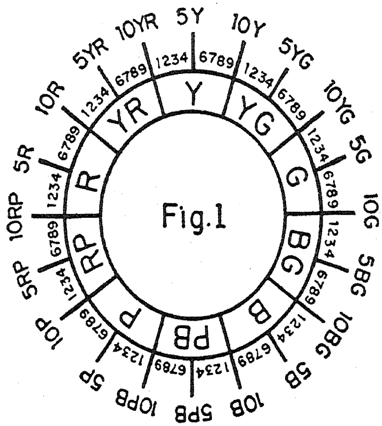


Fig.1

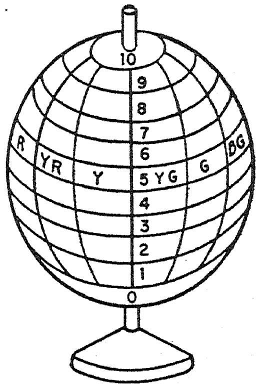


Fig. 2

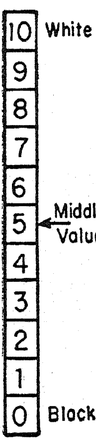


Fig. 3

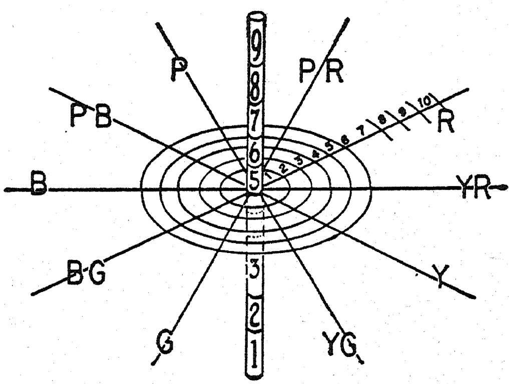


Fig. 4

PLATE 4

achusetts, in 1858, he became an artist of distinction, a gifted teacher, and a man of unusual scientific propensities. He designed a color solid in the form of a sphere in which the physical, physiological, and psychological aspects of color are cleverly organized. His system has many novel features and has gained wide recognition, especially in the United States. It allows for the use of symbols to replace a confusing nomenclature.

In this system every color sensation is united by three distinct qualities which are defined as HUE, VALUE and CHROMA. "Hue" is the name of a color as described in Chapter 2. "Value" is the amount of light in a color, and is used in the same sense as the term "Brightness." "Chroma" is the strength of a color, and is used to express its "Saturation."

Munsell chose five hues—red, yellow, green, blue and purple, which he called the "five principal hues." These five hues were not chosen because they had any particular significance, but because he believed that they were visually equidistant in hue from each other, and because he decided to use a decimal system. The five principal hues were subdivided so that between them were five intermediate hues—yellow-red, green-yellow, blue-green, purple-blue and red-purple. The principal and intermediate hues were arranged in the form of a circle having ten hues, as shown in Fig. 1, Plate 4. By referring to the illustration of the Munsell color sphere in Fig. 2, Plate 4, it will be seen that the pure hues indicated in the color circle are located at the equator. To specify any hue its initial letter is quoted, as R for red, B-G for blue-green, and so forth.

Let us assume that all the hues of the color circle merge into one another by indistinguishable degrees, and it will be easily recognized that the hues may be infinitely divided. For the greater variety and discrimination necessary in color measurement, the dis-

tance between each of the ten hues has been subdivided into ten sections as shown in Fig 1, Plate 4. Thus we have a series of numerals which indicate any practical step or gradation between one hue and another. When writing the symbol for any one of these steps, the numeral denoting the position of the hue on the scale is placed before the letter which stands for the nearest hue, thus: 3G, 7PB, 8R, and so forth. This specifies the first dimension of color — HUE. The numeral 5 always denotes one of the ten hues of the color circle.

In the color sphere, the "north pole" represents white or maximum light, while the "south pole" represents black or the total absence of light. The vertical axis which passes through the center of the sphere from the south pole to the north pole, joining black and white, is a scale of neutral gray values. Black is designated as O, and white as 10, as in the illustration in Fig. 3, Plate 4. Since it is impossible in practical usage to find a black pigment which is totally devoid of light, or a perfectly pure white pigment, these two factors are omitted from the scale and the remaining nine steps form the Munsell value scale. It commences with the blackest black obtainable, which is marked "1," and goes to the whitest white possible with colorants, which is identified as "9." Midway between these two points is number 5, which is referred to as "middle value." These steps of value have been scientifically measured by means of the photometer and follow roughly the principles of the Fechner law, which is simply defined as follows: "In order that the sensations may change in equal steps, or in an arithmetical series, the stimulus — that is the light constituent, must change in equal ratios." For example, if the amount of white in the darkest gray is 4 percent, then a gray series containing 4, 6, 9, 13.5 per cent, etc. of white makes an impression of equal intervals because the white content of every lighter step is 1½ times

that of the previous one.

All colors may be matched in value with the graduated gray scale. Pink, which is a very light red, matches in its white content a gray near the top of the scale and is therefore said to be high in value. Maroon, because it is a dark red having little light content, is low in value.

The quality of "VALUE" is expressed on the scale of neutral gray values, and is written over a line thus: 5/, or 7/, etc.

Pure hues are on a plane which passes through the equator — the location halfway between the north and south poles of the color sphere. They are therefore classified as at middle value. Middle value is indicated as 5 in the value scale. Blue, therefore, as found in the color circle will be written B5/. The numerals 6, 7, 8 and 9 placed after a hue symbol, and over a line, indicate tones above middle value. Numerals 4, 3, 2 and 1 indicate tones below middle value. The letter and the numeral to its left always denotes the hue, and the numeral directly to the right and over the line indicates the value. For example, 3G7/ means number three green in the graduated color circle at value seven.

CHROMA is the third and most subtle quality to be symbolized. It is expressed by the number of the step on the chroma scale shown in Fig. 4, Plate 4, and is written below a line thus: /4, /7, etc. In arranging his ten hued color circle, Munsell did not try to place the most saturated hues in it, but reduced the saturation, or chroma, of all the stronger hues to match that of one which was weakest. In his day, the strongest colorant obtainable was an intense red which, according to Munsell, was about /10 in chroma. Blue-green at its maximum saturation was only half that, or /5. Therefore, blue-green limited the hues at the equator of the solid to chromas of /5.

Try to imagine any one of the hues at the equator moving in towards the graduated value scale which passes through the center of the sphere. It gradually gets grayer, and incidently weaker in chroma, until it reaches the gray scale where it entirely loses its hue.

There are also hues whose chroma reaches out in varying degrees from /5 — 5 chroma. Red-purple may be at 9 chroma, yellow-red at 10 chroma, and some intense reds at 10, 11, or even at 12 chroma.

One is familiar with the marked contrast in chroma between and old brick red and a bright vermilion. Old brick red is a dull red at about 2 chroma, while vermilion is far out at 10 chroma as shown in Fig. 4, Plate 4. These two colors will be symbolized in the Munsell color notation as: Brick red — 8R5/2, meaning number 8 red at 5 value and 2 chroma; Vermilion is written 5R5/10, which indicates number 5 red at 5 value and 10 chroma.

In the Munsell color sphere all hues are located on horizontal levels which extend out from the neutral gray axis. Pure hues are exhibited in the circle around the equator; values in vertical steps from black to white, and chromas in horizontal steps from neutral gray. Thus is constructed a solid in which every horizontal plane corresponds to one value, every radial plane contains colors of one hue only, and the surface of each cylinder concentric with the axis contains colors of equal chroma. With the Munsell color notation, approximate identification of hue, value and chroma may be obtained by direct visual comparison with the samples in the Munsell Book of Color, which shows some four hundred carefully measured colors mounted on charts representing vertical, horizontal and concentric sections through the color solid.

THE OSTWALD SYSTEM

Doctor William Ostwald, born in Riga, Latvia, in 1853, and died in 1932, was world renowned because of his brilliant work in the field of color. He devised a system which standardized colors and fixed them by a notation so that it is possible by means of a number and two letters to give a complete and exact description of any color contained in his solid.

Ostwald graphically represents his concept of the classification and organization of all colors as a double-cone solid, Fig. 5, Plate 5, called the Ostwald Color Solid. On the equator are located the saturated hues. The core of the solid is a scale of neutral grays progressing from black at the bottom to white at the top.

Originally, Ostwald constructed a scale of grays from black to white in ten steps. Realizing that it was impossible to procure a perfectly pure white pigment which reflected 100 per cent of light, or a black pigment which did not reflect any light, he removed these steps and used the remaining eight to form his gray scale. These were lettered in the following manner, commencing at the bottom:—p. n. l, i, g, e, c, and a, as illustrated in Figs. 1, and 2, Plate 5. In charting his gray scale, Ostwald, like Munsell, remembered the Fechner Law and made a series in which white increased in a geometric ratio. In Fig. 4, Plate 5, is a diagram which shows the percentages of white and black in each step.

The hue scale, or color circle, of 24 hues, which Ostwald developed, is based on the four visual primaries — red, yellow, sea-green, and ultramarine blue. These are equally spaced around the circumference of the circle. By mixing yellow and sea-green, leaf-green is produced; mixing ultramarine and red produces purple; mixing green and ultramarine gives turquoise; and mixing red and yellow produces orange. These four additional colors, together with the four visual

primaries, give the Eight Principal Hues of the Ostwald color circle which are arranged in the following order: — yellow, orange, red, purple, ultramarine, turquoise, sea-green, and leaf-green. The eight principal hues are again subdivided into threes so as to form a scale of 24 hues which is graphically shown in Fig. 3, Plate 5.

The 24 standards of hue are numbered consecutively from 1 to 24. The middle hue of each group of three represents one of the eight principal hues.

Connecting the color circle to black and white, as shown in Fig. 1, Plate 5, produces a skeleton of the Ostwald Color Solid. Moving from the circle of pure hues and climbing the solid towards white, we enter the realm of tints, or increasing brightness. Descending from the pure hue circle towards black, we enter the realm of shades, or decreasing brightness. Moving from the pure color circle towards the gray scale the realm of grayed colors is entered.

Ostwald does not consider value and chroma as the essential qualities or dimensions of color, but rather as attributes. He believes that hue, black, and white are the three essential qualities of color, and that all color sensations are mixtures of them. These facts he has stated clearly in the following equation;

$$C + W + B = 1$$

In other words, color plus white plus black gives tone. This is the perfect equation. You cannot add to any one part of it without automatically decreasing the others. For example, let us assume a blue with a definite gray tone. If more blue is added to it, its percentage of black and white content is automatically decreased. If black is added its blue and white content is correspondingly decreased, and if white is added its content of blue and black automatically decreases.

Every possible tone, tint, or shade of any hue is derived from the three elements — hue, white, and

black. These may be charted in the form of a triangle. An equilateral triangle is taken and each side divided into eight equal parts. The parts so marked off are connected in the manner shown in Fig. 2, Plate 5. This results in the formation of thirty-six compartments. In the top corner compartment is white, and in the bottom compartment black is located. The left hand corner compartment contains pure color. White is indicated by W, black by B, and pure color by P. On the PW side of the triangle are pure color, white, and six tints formed by adding increasing quantities of white to pure color. On the PB side are pure color, black, and six shades formed by adding increasing amounts of black to pure color. Along the WB side are white, black, and six grays formed by adding certain increasing amounts of black to white. You will observe that the row of tints is removed as far as possible from black because they contain no black. The shades are removed as far as possible from white because they contain no white, and the neutrals in the gray scale are removed as far as possible from pure color because they contain no color.

In the fifteen compartments in the interior of the triangle are located the grayed colors. These, in conformity with colloquial usage, are called "dull" or "broken" colors. Near the white compartment W are found the pale broken colors. Near the black compartment B are found the dark broken colors, and in the neighborhood of P are the rich broken colors.

All rows of compartments running parallel to PB, the side opposite to W, Fig. 2, Plate 5, represents colors containing equal amounts of white. Those in the PB row will be comparatively dark, but as they approach the W corner, the amount of white in them increases. These are the rows of equal white content and are called "Isotints."

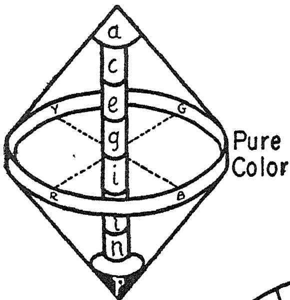


Fig. 1

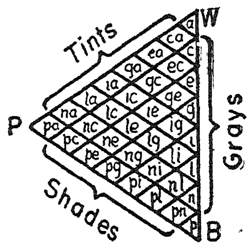


Fig. 2

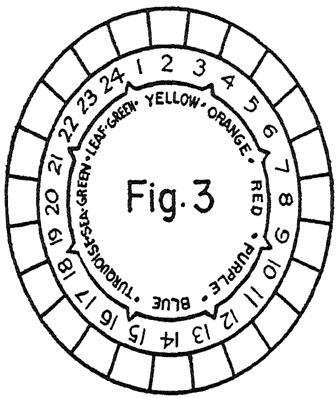


Fig. 3

LETTER	a	c	e	g	i	l	n	p
WHITE	89	56	35	22	14	8.9	5.6	3.5
BLACK	11	44	65	78	86	91.1	94.4	96.5

Fig. 4

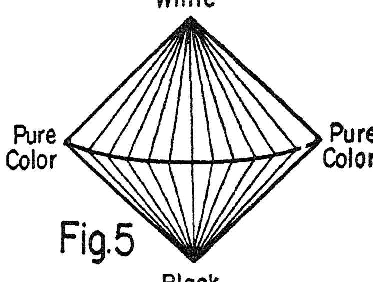


Fig. 5

PLATE 5

All rows of compartments parallel to PW, the side opposite B, represent colors containing equal amounts of black. As the colors of each row approach the B corner, the amount of black in them increases. These are the rows of equal black content and are called "Isotones."

All rows parallel to WB, the side opposite P, represent colors possessing equal amounts of pure color. As each row of colors approaches P, the amount of color in them increases until pure color is reached. These are the rows of equal hue content, or the "Isochromes."

Triangles such as the one just described may be constructed with each of the twenty-four hues of the Ostwald color circle. If they should then be placed in relative order, as they appear in the color circle, so that their neutral gray rows WB merge into one another in the center, and the pure hues form a circle around the outside, we obtain the Ostwald Color Solid which is graphically shown in Fig. 5. Within it are located all the pure hues, tints, shades, grayed colors, and neutrals.

It will be observed that the solid takes the form of a double cone. At its widest girth is the circle of pure colors, identified by the letters — pa, as in Fig. 2, Plate 5. Ascending along the surface of the upper cone towards its apex, all the pure colors become more and more white until they reach white, which is identified by the letter—a. Descending along the surface of the lower cone, the pure colors become darker and darker until black is reached, which is identified by the letter — p. The interior of the solid will contain all the grayed or broken colors. The nearer to the core or axis they are the grayer they become. Ascending, the grays become lighter; descending they become darker. Thus it is that every color has a definite position in the solid and can be identified by means of a

number and two letters. Colors are standardized, and all that is necessary to duplicate a particular one is to state its symbols.

For example, 5ng indicates middle orange, as shown in the color circle in Fig. 3, Plate 5, having an "n" amount of white and a "g" amount of black. In other words, 5ng is a derivative of middle orange containing 5.6 percent of white, 78 percent of black according to the percentage scale in Fig. 4, Plate 5, and, by difference, 16.4 percent of middle orange.

However, such symbols as 5ng, 8ne, 121e, and so forth, do not reveal any definite clue to the identity of the color indicated, therefore, as with the Munsell system, it is necessary to own his color album, charts, and devices to work out the symbols. The Ostwald Color Album contains some 680 tones. By referring to it one is able to find the color indicated by the symbol.

THE BIRREN SYSTEM

Faber Birren, one of the great colorists of the present time, has invented a system of color standardization which is so convenient that it can be efficiently used in all cases where accurate and dependable color standards are necessary.

As the foundation of his system he adopted a color circle of thirteen hues. He took the eight principal hues of the Ostwald circle and divided red and violet, red and orange, yellow and orange, yellow and leaf, and green and leaf. The five additional hues thus created are red-violet, red-orange, yellow-orange, yellow-leaf, and green-leaf. When added to Ostwald's eight principal hues they form a circle of thirteen hues having a perfect sequence all through the entire circuit. Birren calls this the Rational Color Circle. It is illustrated in Fig. 5, Plate 6. Observation shows the complementation point to be off-center. The reason

for this is that true complementaries may be properly accommodated across from each other.

Birren follows the belief of Ostwald that hue, black, and white are the three essential qualities of color, and that all color sensations are mixtures of them. He therefore based his system on the color equation used by Ostwald: $C+W+B=1$, that is, hue plus white plus black equals tone. These three elements when added together always equal 100.

The first step in the system was the organizing of the gray scale. Because it is generally accepted that the average eye can easily distinguish nine distinct steps of gray from, and including, black to white, Birren chose to use a gray scale of nine steps. In developing this scale he first mixed 50 per cent of white with 50 per cent of black to produce a medium gray which he charted midway in the scale. Mixing 50 per cent of black with 50 per cent of middle gray resulted in another gray which was placed halfway between these two, while 50 per cent of white mixed with 50 per cent of middle gray gave another gray which was placed between them in the scale. Midway between the tones of gray thus formed were placed other tones which resulted from a similar process of admixture. Thus a gray scale of nine gradations was formed, as illustrated in Fig. 1, Plate 6. Mixed in this manner, the scale appeared far from being uniform. There were large gaps at the black end, while at the white end the steps were hardly distinguishable.

Realizing this, Birren found it necessary to rearrange the scale so that the differences should be more gradual. He then decided to use the principal of the Fechner Law and plotted the nine steps in a series in which white increased in a geometric ratio. Such a scale is shown in Fig. 2, Plate 6. The numbers to the right indicate the percentage of white to black. How-

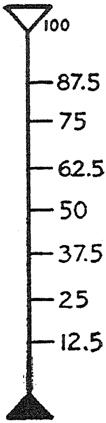


Fig. 1

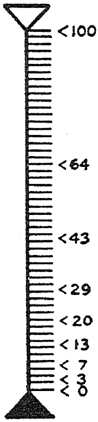


Fig. 2

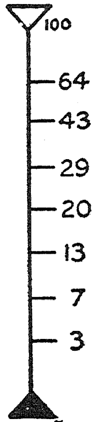


Fig. 3

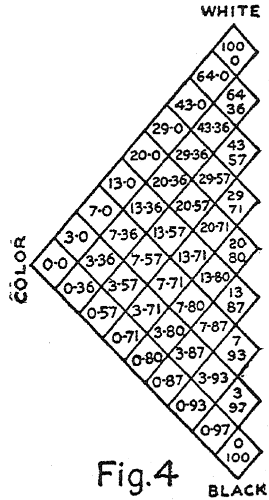


Fig. 4

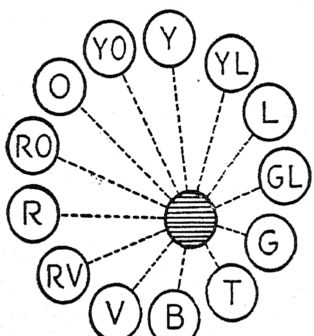


Fig. 5

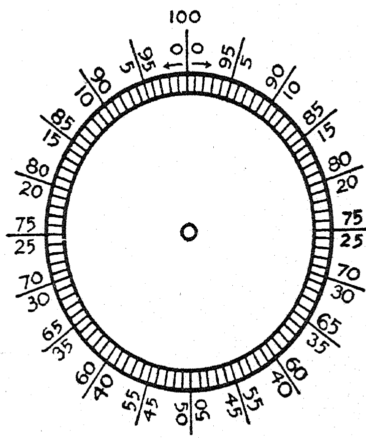


Fig. 6

PLATE 6

ever, grouped in this manner the scale is not very satisfactory for the purposes of color measurement.

In Fig. 3, Plate 6, the steps shown in Fig. 2, have been spread out into equal distances which now shows a perfect rhythm of gradations. From this scale of grays the Birren Color Equation, shown in Fig. 4, Plate 6, has been built up. Color, black, and white, or their abbreviations C, B, and W, are located at the corners of the triangular equation. The gray scale runs vertically at the right of the triangle, the white and black content of each tone being shown as a fraction. For example, 20/80 means 20 per cent of white and 80 per cent of black. Colors having uniform proportions of white, corresponding to the top figure of the fraction in the gray scale, run parallel to C B. Uniform proportions of black, corresponding to the lower number of the fraction, run parallel to C W.

It should be understood that both black and white in the Birren equation are represented by the blackest black and the whitest white colorants obtainable. White is indicated by the number 100-0, and black by the number 0-100. Pure color is represented as 0-0, which means no white and no black. The scale from 0-0 to 0-100, on the lower side of the equation, represents simple shades made by adding black only to the principal color. The scale from 0-0 to 100-0, on the upper side of the equation, consits of simple tints made by adding white only to the pure color. The compartments in the interior of the equation represent colors having amounts of white and black as indicated. The top number of the fraction in the gray scale, and also the first number in all the other compartments, always indicates the white content. The lower numbers in the gray scale fractions, as well as the number following the short line in the other compartments, indicates the black content.

To make the equation workable very little apparatus is required. The essentials are:—

1. Thirteen colored discs, the same as the pure hues in the Birren Rational Color Circle.
2. One white disc and one black disc.
3. A calibrated measuring disc.
4. A rotator or other spinning device, such as that shown in Fig. 1, Plate 2. Birren supplies with his apparatus a mechanically operated spinning device which easily fits the hand and is operated by the thumb.

The white, black, and colored discs each have a slot from center to circumference so that they may be threaded into each other, as shown in Fig. 2, Plate 2, thus allowing varying proportions of each to be exposed.

In Fig. 6, Plate 6, is shown the calibrated measuring disc. It is slightly larger than the others and acts as a background for them as well as a measuring instrument. On the calibrated disc there are two scales running in opposite directions and each marked off into one hundred steps so that percentages may be noted. The clockwise scale may be used to measure the white content of a color, while the counter-clockwise scale forms the means of measuring the black content. No scale is necessary for the color content, as this is always the sum left over to equal one hundred.

Let us now see how the system operates. For example, assume the equation — R-18-3. The symbol which comes first in the equation indicates the pure color in the mixture; the first number after the letter symbol always indicates the percentage of white; and the second number always indicates the percentage of black. R, therefore, identifies the pure color as red. The first number, which in the example is 18, indicates 18 hundredths, or 18 per cent, of white in the mixture. The second number which in the example is 3, refers

to the black content, which is 3 one-hundredths, or 3 per cent. 18 plus 3 equals 21; 21 parts from 100 leaves 79, which is the percentage of red in the mixture. Thus, the symbol R-18-3 indicates a color made up of 79 per cent of red, 18 per cent of white, and 3 per cent of black when spun on the disc.

Sometimes two pure colors are needed for a particular tone. For example, if the tone being matched is neither O-18-29 nor R-18-29, but appears to be somewhere in between them, an equation can be written in which both pure colors are included. In the case just mentioned, such an equation might read O(+20R)-18-29. By analysis, this symbol would indicate a tone containing 20 per cent of red, 18 per cent of white, and 29 per cent of black making a total of 67 per cent. The balance required to make 100 per cent is 33 per cent, which is the amount of orange in the mixture.

The Birren system of color standardization is absolutely flexible. Tones can not only be traced continuously towards white, black, or gray, but also continuously around the entire color circle. No tone need be approximated. It can always be matched and given an exact equation.

Thus we complete our survey of the three most outstanding systems of color measurement and standardization. It is not the intention of this author to comment on them in any way. Each has a definite sphere of usefulness in its particular field. For anyone desirous of further research into the subject, the following books are recommended:—

"A Color Notation," by Albert H. Munsell.
"Color Science," vols. 1 and 2, by Wilhelm Ostwald.
"Color Dimensions," by Faber Birren.

CHAPTER EIGHT

HARMONY AND CONTRAST

To appreciate and produce subtle and refined sequences of color requires a keenly sensitive eye and an alert, artistic, and analyzing mind. The possibilities of color are infinite. When one considers the combinations that may be produced from the saturated hues and their mixtures, and then to these adds the vast number of brightnesses of each, one realizes how difficult would be the task of assigning any limit to the number of harmonious or discordant combinations that the keen minded colorist may desire to employ.

All successful arrangements of color are dependent for their effect upon 1, that which is thoroughly pleasant and satisfying, namely harmony, and 2, that which is unpleasant, namely discord. Most people react favorably to harmonious color schemes, but are shocked by glaring discords. The reaction of the individual to any arrangement of colors is dependent upon the degree of development of the color faculty. People whose sense of color is highly developed feel discords acutely, while others whose color faculties are undeveloped react somewhat less. Hardly anyone is absolutely unconscious of discord.

To be worthy of acceptance for any purpose, applied color must be made interesting and always have an element of drama in it. There are many ways of creating interest, the object being always to obtain a satisfactory degree of variety. Variety does not mean the creation of crashing and startling effects, but rather the use of ingenious methods of harmony and contrast to obtain satisfactory impressions.

Color must have life, movement, and rhythm if it is to command favorable attention. Even though only one color in varying degrees of brightness and saturaranged. Two colors properly combined may increase the liveliness. Three colors increase the dramatic possibilities, while even greater life, movement and rhythm are possible when four colors are properly organized. Color makes color!

Numerous attempts have been made to invent easy and practical systems for the planning of effective color harmonies, and much effort has been expended in order to devise laws and methods to ensure good and acceptable color combinations. The color circle is the means most used for this purpose, but it must be kept in mind that color harmony is not just a matter of selection from this. The arrangement of colors in relation to each other, how much of each, degree of brightness and saturation, as well as surface texture, must all be taken into consideration.

The first step in the development of a color scheme is to decide whether a soft, subdued, and subtle charm is desired, or a vivid, startling contrast of hues. Here the "rule of three" operates again. Arrangements of color may be divided into three general groups:—

1. Monochromatic, or one-color, harmonies.
2. Harmonies of analogous, or related, colors.
3. Harmonies of contrasting, or unrelated, colors.

Monochromatic, or One-Color, Harmonies.—There are occasions where a single color in varying degrees of brightness and saturation may be used for an entire project or scheme. The simplest combination for such a scheme is when one light, one dark, and one pure color are employed, as, for example, orange supported by pale orange and dark orange (brown). If such an arrangement were required for a large area, the effect would be admirable if the principal orange were used sparingly and in points of interest, but supported by

large areas of light orange and correspondingly smaller amounts of brown.

Monochromatic harmonies are especially good when used as backgrounds for brighter tones of other colors. To avoid weakness in one-color harmonies it is a good plan when two light tones of the same color come together to separate them with a line or a band of a darker tone, and when two dark areas of the same color adjoin they should be separated by a band of a lighter tone of the dominant color. One-color themes have the quality of being entirely warm or cool in effect.

Analogous, or Related, Harmonies. — Simple harmonies of a subdued, quiet nature are produced by using related colors. This type of harmony is based on a group of hues, in varying degrees of brightness and saturation, derived from a limited region of the color circle. It is usual to consider two colors that are near to each in the color circle as a minimum, and not more than a third of the color circle as a maximum range, when planning analogous harmonies. There are some colorists who hold to the idea that a related color scheme may even reach a maximum of half the color circle. This is entirely erroneous. A scheme that goes farther than one third range ceases to be analogous because complementaries are thus introduced. We will use blue and orange as an example. These are just beyond the one third limit. Orange in its make-up contains yellow, and this color is felt in the blue-orange combination. Because yellow is the complementary of blue its introduction into a scheme of related hues is inconsistent.

A few combinations of related hues are: —

Yellow __________ is related to orange, yellow-orange, yellow leaf, and leaf.

Green __________ is related to leaf, green-leaf, turquoise-green and turquoise.

Ultramarine______is related to turquoise, blue-turquoise, purple-blue, and purple.
Red____________is related to orange, red-orange, red-purple and purple.
Leaf___________is related to yellow, yellow-leaf, green-leaf, and green.
Turquoise_______is related to green, green-turquoise, blue-turquoise, and ultramarine.
Purple__________is related to red, red-purple, ultramarine-purple, and ultramarine.
Orange_________is related to red, red-orange, yellow-orange and yellow.

When selecting colors for a related scheme, the same principle is used as in the building up of one-color harmonies, but instead of using tints and shades of just one color, related colors are used. All colors selected may be used in different brightnesses, or may be grayed by the addition of a little of the hue directly opposite in the color circle. One hue, however, should act as a key and dominate all the rest.

Interest is gained in schemes of related colors mostly by contrasts of brightness and grayness. The hue that dominates may be supported by a fairly large but subordinate area of a related grayed color and a relatively small area of a pure bright related color. Care should be taken that two or more saturated colors are not used in the same scheme as they are very liable to clash with each other.

The use of two primaries in a related color scheme as, for example, red and blue with the colors situated between them in the color circle, will result in a harsh and crude effect unless one of primaries is greatly modified by either darkening, lightening or graying it. When two primaries are involved in a scheme each demands a good share of the attention and the eye becomes somewhat confused. A more satisfying effect is produced when only one primary hue is used

together with one or more colors made by mixing this primary with another primary and modifying as in the former case. Any hue in a scheme of related colors may dominate, all others being subservient to it.

The Key to Interest.—One-color and related-color themes are apt to become monotonous and uninteresting. The reason for this is because the eye is excessively stimulated in only one part of the visual apparatus without a corresponding stimulation in the other. Because the brain actually does the "seeing" it naturally follows that when it receives an unbalanced stimulation the response must be the same. The brain, and all parts of the nervous system, "feel" this lack of balance and a desire for something to offset it is set up. To satisfy this desire, some kind of variety must be injected into the theme. The best way to obtain this is by means of contrast. Contrast is the key to variety, and variety is the key to interest.

The effectiveness of any combination of colors depends for its continued interest on contrast. The best way to obtain contrast is by using colors from widely separated parts of the color circle. Color combinations that comply with these conditions are generally grouped as follows: —

1. Complementary.
2. Split-complementary.
3. Double-complementary.
4. Triad.
5. Tetrad.

Complementary Themes. — Complementary colors, because they are so totally unlike, give a certain shock to the eye, and because of this quality are very valuable to the colorist. Combinations of such colors need to be thought out very carefully and used with good judgment.

When equal areas of complementary colors are placed side by side they intensify each other and seem

to be filled with a restless vibration, especially where the edges meet. Just imagine, if you can, the shock you would receive on entering a room decorated in full tones of orange and turquoise blue. You no doubt would desire to leave its irritating influence as quick as possible. Suppose, however, that the whole arrangement of these colors was changed by lightening, darkening or graying them, a scheme that is both restful and bright could be produced. The walls may be painted a nice peach color made by adding white to orange, ceiling a lighter tone of the wall color, and trim of either the wall or the ceiling color. Cover the floor with a grayish blue rug. The furniture should be of blond maple and upholstered in rich turquoise blue. Window drapes in turquoise, curtains or Venetian blinds in ecru, cushions and lamp bases in orange and turquoise, and lamp shades in white or ecru complete the new arrangement of our complementary colors for the decoration of a room. What a difference this makes as compared with the previous blatant and irritating example.

The illustration just given is intended to expose the idea behind all good color schemes. Manipulate your colors by lightening, darkening or graying them. When complementary colors are used in a theme it is a good idea to have a dominating area or focal point where all the colors may be brought together in their full saturation. Around this may be grouped larger areas of these same colors in brighter, darker or grayer values.

Split-Complementary Themes.—These themes consist of a color and two other colors situated on each side of its complementary. They are very intriguing and have greater possibilities than direct complements. Beautiful and interesting combinations of split-complementaries are:—

Red-purple (Magenta)—with leaf and sea-green.
Utramarine blue ————with yellow-orange and yellow-leaf.
Turquoise ————with red-orange and yellow-orange.
Orange ————with turquoise-green and blue-turquoise.

Other split-complementary themes may be plotted by means of the color circle.

Double-Complementary Themes.—These also are very interesting arrangements of colors. It is recommended that two rather closely related hues as, for example, yellow and green-leaf, be chosen and that these be balanced by their complementaries ultramarine and red-purple. Other double-complementary color schemes are: —

Red-orange, yellow-green, turquoise-green, blue-turquoise.
Sea-green, leaf, red, purple.
Purple, ultramarine, leaf, yellow.
Orange, leaf, turquoise, purple.
Utramarine, green-leaf, red-orange, yellow.
Yellow-orange, leaf, blue-turqoise, purple.
Purple-blue, magenta, yellow-leaf, green-leaf.

Triads.—The use of three colors as nearly equally spaced as possible in the color circle results in what is called a "triad." In triad color schemes it is best to select one of the colors as the dominant hue and keep the other two in subordination to it. Some very acceptable triad schemes are: —

Yellow, turquoise-green, magenta.
Leaf, ultramarine, red-orange.
Sea-green, purple, yellow-orange.
Turquoise, magenta, yellow-leaf.
Ultramarine, orange, green-leaf.
Purple, turqoise-green, yellow.

Red, turquoise, yellow-leaf.

Orange, ultramarine, green-leaf.

Tetrads.—These make very dramatic color themes. They are indicated on the color circle by centering a cross on the complementation point and selecting the hues to which each arm of the cross points. Examples of tetrads are as follows: —

Yellow, sea-green, ultramarine blue, red.

Yellow-leaf, turquoise-green, purple blue, red-orange,.

Leaf, turquoise, purple, orange.

Green-leaf, blue-turquoise, magenta, yellow-orange.

Dramatizing Color.—Suppose we consider a group of four colors as, for example, leaf, turquoise, purple and orange, and then proceed to arrange them effectively — to dramatize them. In all of the themes we will use turquoise and orange at full saturation, purple will be slightly neutralized, and leaf neutralized at about halfway.

In the first phase of the drama, turquoise will occupy the largest area with brilliant orange in the smallest. In this way, the orange will act as an accent against the turquoise. Slightly neutralized purple and much neutralized leaf will occupy the other areas in unequal amounts but covering less surface than the turquoise and more than the orange.

Phase number two of our dramatization calls for the use of orange in the largest area with saturated turquoise occupying the smallest area and acting as an accent. The neutralized leaf and purple will respectively occupy areas smaller than the orange and larger than the turquoise.

The third phase is a little more difficult, but extremely interesting. Slightly neutralized purple is to occupy the largest area, and turquoise and orange in juxtaposition will occupy relatively small areas and

act as accents. Leaf, the most neutralized color, will occupy an area about half that between the purple and the combined accent colors.

The fourth phase calls for leaf, the most neutralized color in the theme, to occupy the largest area. Purple, turquoise, and orange, all three in juxtaposition, will serve to give accent. This group of accent colors should occupy as relatively small area against a large area of neutralized leaf.

Sketch out a simple design for yourself and try out these themes. You'll be surprised at the results. Other combinations of colors should be experimented with in a similar manner, but remember always to vary your colors, both as to light and dark qualities and the size and shape of the areas. Color must always have an element of drama in it. This will make it capable of creating and sustaining interest.

Harmonizing Conflicting Colors.—Sometimes circumstances arise that compel the colorist to use combinations of colors that clash and conflict severely. In such instances he endeavors to unite them in some way so that their employment becomes more agreeable to the beholder. There are a number of ways of accomplishing this according to the circumstances involved. A few of the most used methods will now be discussed.

1. Neutralize them. For example, green-leaf and red-orange in full saturation used together are restless and unsatisfactory in their effect. They can, however, be greatly improved by mixing with them a neutral color. To find the best color to use for this purpose, locate the color between green-leaf and red-orange in the color circle by moving the longest way around. Going around the circle in this manner we find that half way between the two is ultramarine blue. A relatively small amount of this color will therefore be mixed into the green-leaf and red-orange. Instead of

actually mixing the ultramarine blue into these colors another method is to stipple fine spots or dots of the blue on top of them. In this way the brilliance of the original colors is preserved without their harshness.

2. Mix a little of each color with the other. Bright red and a full green when employed together clash rather badly — they fight like the proverbial cat and dog. If, however, a little of the green is mixed into the red and a little red added to the green, the "edge" is taken off them and they behave much better. Although the resulting hues are less brilliant than the original pure colors they are without a doubt less trying to the eye.

3. "Glaze" them. Glazing is the washing of a transparent color over another colored surface. Blatant combinations of colors when overglazed are softened in their effect although the original hues still dominate. The choice of color for the glaze is a matter that needs some consideration. It may be a neutral glaze the color of which may be found by following the directions outlined in the first method, or it may be a color common to the original ones as, for example, when blues and yellows are glazed with green. Again, if it is desired to "warm up" a scheme of cool colors a glaze of warm browns and reds may be used. A scheme of warm colors may be "cooled off" by using a transparent wash of cool greens and blues.

Illumination may also be used to gain unity amongst jarring colors. By means of tinted lights the colors become bathed in a soft glow which acts in the same manner as an overglaze and pulls them together under its harmonizing influence. This is the way nature works. She takes a green field, a red barn, yellow jonquils and blue lakes, and harmonizes them by flooding them with the golden glow of sunshine. At other times she subdues them by means of a slight haze or gray mist.

4. Separate them with well defined outlines. To lessen the distressing restlessness of inharmonious color combinations an outline is often effective. When such areas are outlined they become strengthened in their relationship to each other since in this way a third color is introduced. The vibration which is always present at the adjoining edges of clashing colors in combination is supplemented in the outline with another color which may be either light or dark according to circumstances.

In effect, an outline may turn sharp contrasts of color into slow gradations of tone, provided it is carefully studied as to hue and width. An example of this may be noticed in stained glass windows. When viewed close to, the lines of the leading separate each patch of colored glass making it glow as a jewel in a setting. When viewed from a distance, the broad neutral lines of the leading seem to unify the sharply contrasting colors so that the whole presents a series of gradations of color having an exquisite glow.

By means of outlines, a group of dull colors may be made more interesting and often exceedingly brilliant by introducing dark or light outlines.

5. Use a rough texture. When colors that conflict have to be used together, a rough textured surface often proves valuable. Such a surface has a tendency to blend the colors together because of the variations in light and shade which it presents. The highlights cause an even brightness to be diffused over the entire surface, and the shaded depressions tend to cast a slightly grayed tone over it. This, because it gives all the colors something in common, makes them harmonize.

Balance.—The most important essential for good arrangements of color is balance. It is the dominant idea behind all successful color schemes. The ability to produce a properly balanced combination of colors is by

no means simple. It calls for much thought, but the ultimate effect of a well balanced color scheme is indeed worth the effort put forth to obtain it.

Balance is the securing of unity in the midst of variety. Both variety and unity are necessary to sustain interest, and these opposing forces must be balanced. Variety is necessary to attract and arouse interest; unity is essential to create a favorable impression and to satisfy the moods and desires. Variety overdone is confusing and unpleasant; unity overdone is monotonous. The mark of good color arrangement is in knowing where to stop between these two extremes.

Every color used in a scheme should be considered as having weight. Thus, a small area of light color will balance a correspondingly large area of dark color, and a small area of dark color balances a correspondingly larger area of light color. Large areas of color should generally be quiet and subdued in effect, while smaller areas may show striking contrasts. When brilliant colors are part of a scheme, a sufficient amount of dull color should also be used to make an effective setting for them.

Balancing on Gray.—There are some colorists who believe that for comfort and agreeableness a color scheme should balance on a neutral gray. For example, all the colors used in a decorative scheme, when painted on the Maxwell disc in proportionate areas to those they occupy in the scheme and then spun on the rotator, should all merge together into a neutral gray. If they fail to do this they are said to be unbalanced. This idea should not be taken too seriously. It is probable that such a rule will not produce any bad combinations, but it is very true that many good combinations will violate this rule. Go outdoors and take a look at the glorious pageant of color that nature so lavishly displays. She does not seem to be at all con-

vinced about balancing on gray. We know that the world's greatest masters of painting did not countenance such an idea. Moreover, this rule does not permit of the production of dominant color moods in color arrangements. If you want to be free and original discard such restricted, hard-and-fast rules as having very little esthetic value.

Centers of Interest.—Whether painting a picture, decorating an interior or doing anything that requires the use of colors in combination, the idea to keep in mind is that there should be some part, or element, of the arrangement that can be used as a center around which the rest of the scheme seems to be more of a background.

For example, on entering a room, the eyes, after glancing around at the general furnishings, should be attracted to some point on which they are brought to rest. A brightly colored vase, a bouquet of flowers, a number of fine books between appropriate bookends, or a gaily colored picture, are all admirable for this purpose.

It is a well known fact that bright red and pure yellow have great color impact—they appear to advance unmercifully. It is for this reason that they are so prominantly featured on signs and billboards. Suppose you were painting a poster design in which a pretty girl must constitute the center of interest. Dress her in either red or yellow and you have already given her interest and emphasis. Should your choice of color be yellow, and you wish to further heighten the emphasis, place the yellow dress against a background of blue—the complement of yellow. Of course such a combination will be extremely bold. To gain emphasis of a quieter type, slightly neutralize the background by adding some yellow to it. In all such cases, always remember that the surroundings should be less asser-

tive than the point which is intended to be the dominating factor.

These observations, however, do not necessarily imply that every color in a scheme, except those forming the point of interest, should be of low contrast value. Other parts of the scheme may even have colors that are as bright as those in the point of interest, but they should not be so obvious as to detract the attention from it.

CHAPTER NINE

MAKING COLOR LIVE

Nature's Color Is Alive— Colors of natural objects are characterized by their infinite variety of texture and hue. Seldom do we find anything flat and lifeless in nature. She mingles and interweaves her color with ever changing and infinitely gentle gradations of hue, constantly surprising the eye, and maintaining its interest.

Well do I remember a vacation trip into the vast spaces of open country when nature seemed to be filled with joyous abandon. The vision of sunny, blue-tinted sky above, the waving grass and yellow grain all around filled me with a deep reverence for the Creator's wonderful handiwork. I climbed to the top of a hill and stood there, letting my city-cramped soul stretch itself. My heart rejoiced as I drank in the sights around me. It was a never-to-be-forgotten experience. Tiny white clover grew close to the soil, black-eyed Susans raised their heads above the vegetation of the fields, and morning glories crept along clinging to fence and bush. Far away in front of me was the misty, cool, blue of distant mountains. To my right bright masses of blue cornflowers made me catch my breath, and to my left a drift of snowy daisies ran down the hillside. I turned to look back, and there behind me, stretching to the horizon's rim, was more yellow glory: wheat ripening in the sun. Here was splendor, the kind that artists love to paint, a Van Gogh landscape gone mad with color.

Even in small areas nature's color is full of interest and vitality. The petal of a red rose will, on close examination, reveal traces of red-orange and magenta.

A leaf may show more than just green. Variety of surface texture, translucency, infinite gradation of tone, and often sparkling points of red, add a richness to the greenness that is impossible of attainment with a plain flat tone.

Alongside the petal of a purple pansy, hold a piece of colored paper that matches the color of the petal as closely as possible, and observe how much richer and full of vitality the petal's color is. Closer examination of the petal shows that what at first appeared to be a smooth area of purple is full of gleams of unexpected gem-like bits of magenta and turquoise. It is these that impart the exquisite radiance to the coloring of the petal as against the lifelessness of the paper's colored surface.

Nature is unsparing in her color renditions. There is no climate, no place, or scarcely an hour, in which she does not exhibit color which no mortal effort can imitate or approach. John Ruskin, the great art critic and philosopher, in his literary work "Modern Painters", presents an inspiring account of a gorgeous sunset that would tax the ingenuity and patience of the most gifted artist in the effort to reproduce it.

Quote—"It is a widely different thing when nature herself takes a coloring fit, and does something extraordinary, something really to exhibit her power. She has a thousand ways and means of rising above herself, but incomparably the noblest manifestations of her capability of color are in those sunsets among the high clouds. I speak especially of the moment before the sun sinks, when his light turns pure rose-color, and when this light falls upon a zenith covered with countless cloud-forms of inconceivable delicacy, threads and flakes of vapor, which would in common daylight be pure white, and which give therefore fair field to the tone of light. There is then no limit to the multitude, and no check to the intensity, of the hues

assumed. The whole sky from the zenith to the horizon becomes one molten, mantling sea of color and fire; every black bar turns into massy gold, every ripple and wave into unsullied, shadowless, crimson, purple, and scarlet, and colors for which there are no words in language, and no ideas in mind—things which can only be conceived while they are visible—the intense hollow blue of the upper sky melting through it all—showing here deep, and pure, and lightness; there, modulated by the filmly, formless body of the transparent vapor, till it is lost imperceptibly in its crimson and gold."

In contrast to this example of riotous color, it is strange how marvelously nature varies the most general and simple of her tones. A mass of distant blue mountain seen against the light, may, by comparison with other parts of the landscape, at first appear all of one hue. But look how that blue is made up. There are dark purple shadows in it under the crags; there are gray half-lights upon the rocks, and faint touches of stealthy warmth along their edges; there are green shadows across the vegetation; every bush, every stone, every tuft of moss has its voice in the whole scheme, and contributes its part to the characteristic blue tone.

Making Your Colors Live— Artists are continually striving to produce with paint the complexity, gradation, and vitality which are ever present in nature. The most successful way to achieve these desirable qualities is to do as nature does. Diffuse, or mingle, into the dominant color some related color. For example, suppose you desire to match with paints the color and life of an orange nasturtium. Even the most powerful and beautiful pigments will fail to accomplish this if they are painted on in flat tones. However, if you make dots or markings of yellow and red mingle with the general orange tone, so that they are not thoroughly

mixed but simply flow together and mingle, the resulting play of hues will give a more persistent sensation of orange having the peculiar liveliness of the nasturtium flower.

As a guide to those who would use this method of adding life and vibration to their color work the following table will be found very useful: —

Yellow—
- for low vibration use minglings of yellow-green and yellow-orange.
- for higher vibration use minglings of green and orange.

Orange—
- for low vibration use minglings of yellow-orange and red-orange.
- for higher vibration use minglings of yellow and red.

Red—
- for low vibration use minglings of vermilion and magenta.
- for higher vibration use minglings of orange and purple.

Purple—
- for low vibration use minglings of magenta and ultramarine.
- for higher vibration use minglings of red and turquoise.

Blue (turquoise)—
- for low vibration use minglings of blue-green and ultramarine.
- for higher vibration use minglings of green and purple.

Green—
- for low vibration use minglings of yellow-green and blue-green.
- for higher vibration use minglings of yellow and turquoise.

If still higher effects of vibrancy are desired, use along with the colors suggested in the above table, some of the complementary of the principal color. The result may lack some of the purity of the previously mentioned examples, but this will be more than compensated for by the increased liveliness which results.

Lively Neutrals Produced By Minglings.—We know that when complementary colors are mixed together they neutralize each other and produce a gray. This is the opposite to the effect produced when complementaries are allowed to mingle rather than to mix. Each intensifies the other. Suppose we produce a gray by mixing together proper amounts of yellow and purple pigments. The result, although perfectly neutral, does not compare in life and sparkle with a similar mixed neutral gray into which a little of each of the components yellow and purple has been allowed to mingle. A gray thus produced by minglings becomes permeated with a tremulous vibrancy which makes it appear almost as suppressed color, full of delicate, shifting, elusive hues, rather than neutrality.

Minglings of crimson and blue-green also produce a neutral in which the two colors lose their identity but impart a glow which would be lacking in a straight mixture of them.

Natural Order of Hues.—If the color circle in Fig. 1, Plate 1, be examined it will be observed that yellow, the brightest of all hues at full saturation, is at the highest point. Blue-violet, or ultramarine, the darkest of the saturated hues, is at the lowest point. One may travel between these extremes in two ways, either by way of the warm reds or by way of the cool blues. The natural order of progression down one side is for orange to be lower than yellow because it is of less brightness, red lower than orange for the same reason, and so on down to blue-violet or ultramarine. On the

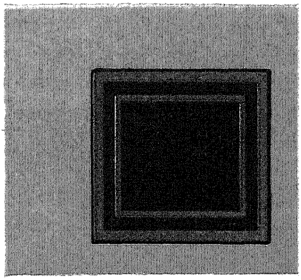
other side, the natural order is for green to be lower than yellow, turquoise lower than green, and so on down to ultramarine.

	Yellow	
Yellow-orange		Yellow-leaf
Orange		Leaf
Red-orange		Green-leaf
Red		Green (sea-green)
Red-purple or Magenta		Turquoise-green
Purple		Turquoise
Purple-blue		Blue-turquoise
	Ultramarine blue	

Discord.—It seems as if discord is a necessary element in modern life. When everything is running smoothly we soon tire and become impatient, but are fascinated and charmed when unexpected things happen. Color lends itself admirably to the creation of startling effects which would stimulate the beholder and add feeling of action and vitality.

Any color which in the natural order of progression in the color circle would be lighter or darker than its neighbor becomes a discord when that order is reversed. For example, pale blue dots on a dark yellowish-green background would form a discord because there is an unnatural sequence. The natural order would be for the blue dots to be darker than the yellowish-green. For the same reason, a small area of very light purple surrounded by a comparatively large area of saturated orange would be very displeasing.

Discords need not necessarily be something ugly and distasteful. In a musical composition, discord is seldom, if ever, used as the whole theme. It is employed in such a manner as to add an element of shock and stimulation at certain intervals. The general rule regarding musical discords is that they should be resolved into, or be followed by, concord or pleasing harmony. As in a musical composition, so in a color



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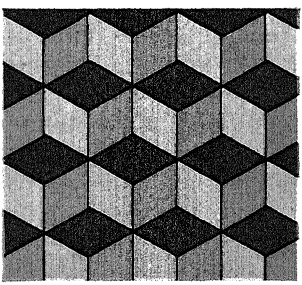

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1. A brilliant arrangement of contrasting hues which departs from the usual conventions in the harmony of red.
2. An arrangement of related hues—orange, with red and red-violet, which is exceptionally warm and luminous.
3. Shows how the simple handling of black shadows gives the colors a very intense and lustrous appearance.

scheme, that which satisfies should dominate, discord being employed as a means of attracting the attention to some particular point. Discord, therefore, may be considered as an accessory. Rightly used it stimulates interest; wrongly used it "grates" on the nerves. Discords should only be employed when a color scheme tends to become dull and heavy.

Rhythm and Movement.—Harmony, balance, and rhythm are the underlying factors in every acceptable color scheme. We have already considered harmony and balance in chapter six. Color rhythm is the feeling of related progression from one hue to another. Rhythm and movement are inseparable, in fact, **rhythm is movement.** If you cover one half of the color circle on Plate 1 with a sheet of paper so that it cuts through yellow and ultramarine, you will observe a ryhthm of hues that moves either from ultramarine through blue-green to yellow, or from ultramarine through red and orange to yellow, depending on which half is covered. Whichever rhythm is exposed, as the gaze travels from ultramarine to yellow there seems to be a sort of moving from darkness towards some source of light just beyond the yellow. When the gaze moves from yellow through the series to ultramarine, the impression is of passing from light into shadow. Both these rhythms of hue give a feeling of movement with a suggestion of continuity beyond.

Any gradation of colors from light to dark suggests a movement from illumination to shadow, and from dark to light the suggestion is of moving towards illumination. A gradation from red through yellow to turquoise gives the impression of approaching the light from one direction and going away from it again towards shadow in the other. A rhythm of hues from red through ultramarine to turquoise suggests a movement from warm light to shadow, passing through it, and emerging towards cool light.

When considering movement, the fact that warm colors have the greater power of attraction must be taken into consideration. If both warm and cool colors are used in a scheme the eye somehow always moves from the cool to the more active warmer colors, and from dark to light. Movement within the cool range is slower, quieter, and might even be sluggish in contrast to the more rapid movement found in the warm, active color group.

Thinking of movement in color we comprehend how it is possible to set up a whirlpool of action, or reduce activity to slothfulness. Just as a violent chord in music arrests the attention and stimulates action, so does a violent color arrangement. Complementary colors, when properly handled, can be used to affect a crash or shock. They instantly pull the attention away from all else and demand quick attention. A gradation of related hues generates a slower movement and retards interest in some place in order that it may be more easily centered at some vital spot. Thus, color movement may be successfully directed to attention anywhere desired.

Achieving Successful Color Arrangements. — Color sense is a gift of nature, within your power to win. You may gain it in two ways, both equally good. It may come as a heritage of birth along with the rest of your powers. If this is the case, treasure it and develop it or you may lose its subtle influence. Failing possession of it at birth, you may acquire it by your own efforts as many others have done.

Study the works of good colorists. Note the way they express themselves. In considering what others have done you will be better able to avoid what is bad and adapt that which is good to your own needs. The designing of houses is an example of what is meant by this. Millions of houses — good, bad, and indifferent — have been designed and constructed since

we got away from the habit of living in caves, and the best of the architects were those who had the good sense to make use of the successful ideas of others in their own plans.

Just as there are infinite possibilities of improvement in the planning of houses, so it is still possible to develop better color arrangements than have ever been devised. Knowledge is constantly being added to knowledge, and the earnest student of color who adds his practical skill to the best of others is most likely to succeed in the art.

In all your color work the inventive and imaginative faculties must be called to work and allowed full play. Cultivate these faculties. Use your mind, it is the one thing that lifts man above the beasts. Make yourself mentally efficient, and try to effectively reason out all matters relating to discriminate color harmony, being guided always by the closest observation of nature, the works of distinguished colorists, and the principles expounded in this book.

CHAPTER TEN

TURN ON THE LIGHTS!

Color, in its expressiveness and impressiveness, is a fascinating subject, and no discussion of it would be complete without some reference to the great potentialities of colored lighting. Color and light are inseparable. Without light there is no color. Illuminating engineers have been and are still trying to make more and more effective lighting arrangements. Since the days when man depended entirely on the sun, and the first flickering, smouldering flame of a pine torch released him from the domination of daylight, he has ever been trying to turn night into day.

It is hard to comprehend the fact that it is only within the last seventy years, or at most a hundred years, that man has had available means of producing artificial light in any appreciable amount. In the year 1800, Sir Humphrey Davy invented the electric arc. The first incandescent lamp was made by Thomas Edison in 1879, and these were produced commercially for the first time in 1881. It was not until Edison's invention of the electric lamp that overwhelmingly rapid developments in the technique took place. It opened up unlimited possibilities, and illuminating engineers were not slow in taking advantage of its possibilities.

Every application of artificial illumination presents its own problems. Public libraries, designed for reading comfort, are not illuminated in the same way as lecture halls. Churches call for entirely different lighting conditions from theaters. In factories where individuals operate special machines, the problems of illumination are much different from those encountered

in a department store. The modern application of electrical advertising calls for certain esthetic demands upon the illuminating engineer that are not very necessary when dealing with street lighting. These, and many others, are the everyday cases which have to be considered when we "turn on the lights."

Effects of High and Low Illumination.—Illumina-is worthy of much consideration. We know that surfaces owe their color to the fact that they have the power to absorb certain rays of colored light and to throw off, or reflect, others. In ordinary daylight, colored surfaces are able to absorb practically all those rays to which they are especially susceptible, and as a result, the rays that they reflect, and which give them their characteristic color, are fairly pure and unaffected by any other rays.

Bright illumination tends to decrease the saturation of colors besides affecting their brightness. When the illumination becomes intense, the flood of light is so great that the surface upon which it falls cannot absorb all of it. The unabsorbed light is largely reflected, and we see not only the rays characteristic of the color of the surface, but also a certain amount of all the other rays. For example, if the surface is turquoise that hue will predominate but will be accompanied by so many other rays that the purity of the color will be affected. The turquoise colored surface will be brighter because it reflects a greater amount of light to the eye than under ordinary illumination, but will be less pure because of the additional colored rays reflected.

In low illumination or deep shadow, all hues seem to take on suggestions of violet, and in extreme gloom appear neutral. The reason for this is because the surface receives such a small amount of light that it has little to reflect. In high illumination colors usually appear more yellowish, red takes on an orange hue,

blue becomes greener, while violet is lighter and rather bluish. As illumination decreases, red and blue show traces of violet, green becomes bluer, and orange appears brownish. Yellow shows the most illusive changes under high and low illumination. In high illumination it tends towards a greenish white, while in low illumination it sometimes suggests green and at other times orange. In shadow it ofen takes on a slightly neutralized appearance as if some of its complementary ultramarine had been added.

Effects of Colored Illumination.—Changing light conditions have considerable effect on most colors. Pure, brightly colored surfaces are the least affected or distorted due to their extreme saturation. However, when a pigment hue is modified with white, black, or its complement, its selectivity and absorption qualities are relatively reduced, and it thus becomes more susceptible to distortion by changing light conditions.

A pertinent example of the effect of illumination on colored surfaces may be found in the color tone commonly named "Mauve," which is made by adding white to purple. Studying this color in ordinary daylight it appears predominantly blue with a decidedly reddish undertone, and may under these conditions be described as a mixture of blue, red, and some white, with emphasis on the blue, making it dependent for its existence upon the blue portion of the daylight. If the mauve sample be now viewed under the warm reddish glow of incandescent light a striking change in its characteristics will be seen. It loses much of its blue tone and appears as a dull, grayed, red.

Another example of the effect of illumination on colors is the warming effect of peach color on the walls of a poorly lighted north bedroom, which color can become very distasteful in a room receiving a large amount of sunshine.

The importance of illumination in its effect on colored surfaces cannot be too strongly expressed. Let us assume that a large uninterrupted wall area has been painted with one of the new green pastel colors. In order to maintain this hue perfectly on every part of the wall's surface it is necessary that it be illuminated at every point throughout its entire length and height with the same quality of light. Now, if we divide this painted wall into four separate areas and illuminate each one with a different type of light, we would have four distinct hues instead of one.

By the use of lights of various colors, surfaces can be made to change in hue and tone at will. To illustrate this, try the following experiments. Examine the color circle on Plate 1 through a piece of red glass. The red in the color circle will appear very bright, and all other colors in the red area will also appear fairly bright because the red rays which these colors reflect pass readily through the glass. The green will be entirely neutralized because it does not reflect any red rays, while colors in the neighborhood of green will be reduced in intensity. Yellow and blue will be somewhat dulled, the yellow becoming reddish and the blue leaning toward violet. Again, should the same color circle be viewed through a green glass the effects just described will be reversed, and the green area will be heightened in brightness while the red area will be neutralized in varying degrees.

Similar effects may be observed by using colored lights to illuminate the color circle. Illuminating an object with light which is related in color to it increases its brightness. When colored light falls upon an object the color of which is complementary to the color of the light, the object's color is completely neutralized. An understanding of these facts makes it possible to arrange a display or to paint a picture so that by changing the color of the illumination an

entirely different effect may be produced. A painted or printed design can be made to disappear and reappear at will merely by changing the color of the light which falls upon it. Suppose we take a white card and paint a design on it in red and blue. If this is illuminated by correctly toned red light, the red portion of the design becomes invisible and only the blue shows. Should the same design be illuminated with blue light, the blue will disappear and only the red will be seen.

On Plate 7 is a chart which tells the approximate effect of some colored lights on various colored surfaces.

Electrical Advertising.—There is something about the flaming light and color of modern electrical advertising that stirs even the most sophisticated city dweller. It causes one to wonder who was responsible for that myriad-hued theater display — whose idea was this gaily colored, animated, spectacular — and what was the purpose behind it all.

The application of electrical advertising is indeed wide in its scope. The seller of merchandise has grasped its infinite possibilities and adopted them in every possible way to his requirements. Judiciously used, it makes for more intelligent buying, which leads to permanent, satisfied customers. Merchants testify to this fact.

To be most effective, electrical advertising displays should incorporate as many as possible of the following characteristics: —

1. Brightness. One is naturally attracted to those objects that are brightest. In this era of high speed brightness is an important factor. With modern light sources, we have our choice of almost any brightness —from a sign that is just bright to one that successfully dominates its surroundings.

PLATE 7

PIGMENTS

LIGHTS	YELLOW	ORANGE	RED	PURPLE OR VIOLET	BLUE	GREEN	YELLOW-GREEN	LIGHT-BLUE	LIGHT-RED
YELLOW	BRIGHT YELLOW	YELLOW-ORANGE	BRIGHT RED	DARK NEUTRAL	GREENISH	BRIGHT GREEN	YELLOWISH	LIGHT GREEN	ORANGE
ORANGE	ORANGE-YELLOW	BRIGHT ORANGE	SCARLET	PURPLISH GRAY	REDDISH GRAY	GRAYISH YELLOW-GREEN	YELLOWISH GRAY	LIGHT GRAY	ORANGE
RED	LIGHT ORANGE	RED	BRIGHT RED	RED-VIOLET	PURPLISH	GRAY	LIGHT REDDISH GRAY	PURPLISH	RED
GREEN	BRIGHT GREEN	NEUTRAL-IZED	YELLOW-BROWN	GREENISH GRAY	GREENISH BLUE	BRIGHT GREEN	GREEN	LIGHT GREEN	LIGHT GRAY
BLUE	GREENISH GRAY	PURPLISH NEUTRAL	PURPLE	DARKER	BRIGHT BLUE	BLUE-GREEN	BLUE-GREEN	BLUE	LIGHT PURPLE
PURPLE OR VIOLET	REDDISH NEUTRAL	SCARLET NEUTRAL	MAGENTA	BRIGHT PURPLE	PURPLISH	GRAY	REDDISH GRAY	PURPLE	PURPLE

2. Legibility. Proper design and letter size, together with good color and correct brightness, assure legibility.

3. Color contrast. Color adds beauty and a powerful appeal. Contrast helps to make a display stand out from its surroundings.

4. Individuality. Sameness of color, brightness, and design nullify the effectiveness of an illuminated display.

5. Motion. Movement of any kind never fails to attract people, and, what is more, an electrical advertisement in which lights are turned on and off uses less energy and therefore lowers maintenance costs.

The widest use of electrical advertising is in the field of illuminated signs. These are generally understood to indicate signs in which the letters, numerals, ornaments, or borders are built up by means of electric lamps or gaseous tubes.

Reflected-Light Signs.—The simplest of all illuminated signs are what are known as reflected-light signs. They are usually flat surface signs having the lettering and design painted on them. Lamps are located either in a hooded top, or in projectors having lamps and reflectors, or along the edges with direct sight of them being prevented by a projecting wall or a series of louvers. For best effect the light bulbs should be placed as close together as is practical. Gaseous tubes are admirable in these signs when the lighting is directed from the edges of the hood.

Exposed-Lamp Signs.—These are signs in which the design or lettering is outlined by visible luminous tubes or in points of light from visible lamps. The principal forms are: —

1. Flush pattern, in which the design and lettering are painted on the container, and the lamp sockets are inserted and made flush with the surface at intervals along the strokes of the letters or design. Another ar-

rangement of the lamps is to have them located along the outlines of the letters or design. If the lamps are spaced near enough together, the design will be seen in light.

2. Cut-out pattern. This is a standard type used on large roof signs. The letters are usually mounted as separate units or an open metal framework or on the face of some structure. The lamps or luminous tubes are located either along the surface of the letters or arranged as outlines. These signs are particularly effective at night over great distances. The chief objection to them is their ugly daytime appearance.

3. Trough pattern. In this type of sign the letters or design are outlined with thin walls of sheet metal so as to form troughs or channels. The trough must be at least deep enough to cut off all direct light at angles greater than ninety degrees from the vertical axis of the lamps if it is to be properly effective. These signs have advantages over the others in that they increase the brightness contrast between the lettered design and the background by shielding the light from the background. They are easy to read because they confine the light where it is designed to be. By giving depth to a sign they improve its daytime appearance.

Enclosed-Lamp Signs.—Another familiar type of electric sign is the enclosed lamp, or "box"sign. These signs often consist of a container or box, the entire face or faces of which are made up of heavy plate glass on which the design is painted. The majority of the better-class enclosed-lamp signs have metal containers, the faces of which are cut away according to the lettering or design, behind which opal glass is placed. A finer effect is obtained when individual opal glass letters are inserted in the cutaway parts. Enclosed-lamp signs are illuminated from the interior, the light being permitted to escape through the cut out parts. Simple flashers can be installed in them to add

to their effectiveness. A flasher is a mechanical device which flashes lights on and off. When flashers are used in combination with colored lamps, motion is produced — moving light — which strengthens the sign's power to attract the attention of the passer-by. Gaseous tubes are very practical illuminants for enclosed-lamp signs.

Because this type of sign is generally viewed from much shorter distances than exposed-lamp signs, the containers used in the better class signs are usually ornamented so as to avoid the tin box appearance, and designed so as to be in complete harmony with the structure on which they are placed. The brightness of these signs cannot compare with that of exposed-lamp signs but this is largely compensated for in its artistic daytime appearance to the viewers who pass close to it.

Spectaculars.—From the simple types of electrical signs which we have just reviewed, it is a far cry to the brilliant creations to be seen in most large cities and which cost a fortune to build, operate, and maintain. Motors and flashers of tremendous power and intricate mechanisms are used to produce amazingly spectacular effects, such as swimming tropical fish, fountains, waving flags, exploding fireworks, and even a baseball game, in full color and motion. Spectaculars are highly technical in construction, and as an evidence of modern mechanical ingenuity they are supreme.

Color in Electrical Advertising.—Color adds beauty and appeal to a sign or display. It also makes it stand out from its surroundings. The clear, brilliant colors and glowing whites give light and life, and have great attractive power, especially if made to contrast vividly with other signs in the vicinity. Color, when properly handled, increases legibility.

When using color in electrical advertising, great care must be taken to insure equality of impression in the various colors. Some do not "carry" very well, becoming illegible before others. Furthermore, the eye is not equally sensitive to all colors. A yellow-green light, for example, produces a greater lighting effect than red or violet light of the same intensity.

White lamps radiate white light. White light is a combination of all colors. By filtering out colors which are not required it is possible to obtain light of any desired color. Colored paints, lacquers, etc., colored glass, colored celluloid, and colored gelatine are forms of color filters. Red glass absorbs the greater part of all colors except red, which it allows to pass through. If this red glass is placed in front of an electric lamp it acts as a filter, holding back all the light from the lamp except the red rays. These pass through in the form of red light. When colored light is obtained by filtration in this way, it is not so intense as the original white light. To compensate for this deficiency, and to obtain equivalent relative brightness, lamps of different sizes and intensities must be used. In some instances equality of brightness is not desirable, in which case all that is required is to decide upon the brightness desired and then to select the right lamp for this purpose.

Luminous Tubes.—Most of the modern illuminated sign creations make use of gaseous tubes. This type of illuminant has made great inroads into the business heretofore monopolized by the manufacturers of electric bulbs. Without appearing technical, but using the layman's point of view, an outline of the development of this type of illuminant will be given.

The discovery in 1895, by a Swedish chemist, of a method of producing a temperature so low that air could be liquified, made possible the development of the luminous-gas tube. Sir William Ramsey (1852-

1916), Professor of Chemistry at University College, London, England, and a Nobel prize winner in 1904, discovered argon, thereto an unknown constituent of the air. Later he discovered other atmospheric gasses such as kripton, xenon, and neon. By a process of evaporation, lighter gasses were first passed off, and and the heavier gas which remained was called "neon," from the Greek word that signified **new**. Its extraction and separation from other gasses was costly and not at all satisfactory, and its use was largely of an experimental kind until 1910, when a Frenchman named Claude invented a process whereby it was possible to produce neon gas at low cost, thereby making it a commercial possibility. The process was patented in the United States in 1916, although the application was filed in 1912. By exhausting the air from transparent glass tubes and filling them with neon gas, then applying a suitable electric impulse, a brilliant red-orange light was produced.

The first Neon signs appeared in France in the year 1921, and the first one used in the United States, as far as seems to be known, was erected in San Francisco in 1922 for the Packard Motor Company. This sign was manufactured in Paris, France.

Neon tubes have found a wide application in the illuminating of theater marquees and the outlining of buildings, besides their use in signs. Bright sunshine seemingly has no effect in dimming the luminosity of them, and because of this, as well as the low operating cost, many merchants keep them in operation both day and night. The use of the term "neon," although so general, is incorrect, as other gasses have been commercialized for use in luminous tubes. The most popular of these are argon, helium, kripton, and xenon. They have made possible the production of almost any desired color instead of the red-orange first exclusively obtained. A neon-filled tube containing a

small amount of mercury produces a beautiful sky-blue glow, and when amber glass is used with this combination an attractive green is created. With the employment of various gasses used separately or in combination, as well as tubing of different colors, almost all hues can be produced. The following are the most popular colors:

1. Red——neon gas in plain glass tubing.
2. Deep red——neon, or a white gas, in deep red tubing.
3. Pink——pink gas in plain tubing.
4. Orange——neon gas in amber tubing.
5. Yellow——white gas in amber tubing, or gold-colored gas in plain glass tubing.
6. Green——argon-mercury gas in amber tubing.
7. Sky-blue——argon-mercury in plain glass tubing.
8. Deep blue——white or blue gas in deep blue tubing.
9. Purple——neon gas in blue tubing, or blue gas in red tubing.
10. White——helium gas in plain glass tubing.

Fluorescent Tubes.—As has already been stated, the usual method of obtaining certain colors in gaseous tube illumination by filtration is not one hundred per cent efficient because much light is lost. For example, when the light from argon-mercury gas is filtered through amber colored glass in order to produce green light, less than one half of the light intensity of the original argon-mercury illuminant is obtained. A successful method of overcoming this loss, and thereby giving a light of maximum brilliancy, has been developed in a special type of glass tubing which utilizes the property of "fluorescence," a subject which will be fully discussed in Chapter 10.

There are certain substances, notably zinc sulphide, calcium tungstate, and the silicates of zinc and cadmium, which when properly treated, possess the property when exposed to ultra-violet light, of re-emitting this invisible radiation in the form of visible light. These fluorescent substances are coated on the inside of the glass tube. The method of coating varies with different manufacturers. In one method of manufacture, the fluorescent materials are introduced into the structure of the glass before it is drawn into tubes. Such tubes are double-walled — formed with two layers, the outer one being opal diffusing glass of the required color, and the inner one containing the fluorescent substances. Whatever the method, the result desired is a thin, firm, coating of fluorescent material which will adhere to the glass under all conditions encountered by the tube during bending, pumping, and continued operation.

The filling gas in fluorescent tubes is mercury vapor, with argon or other gas or mixture of gasses, as the carrier. When the electric current is turned on, the inner coating of chemicals in the tube will glow or fluoresce, under the bombardment of ultraviolet rays produced by the mercury vapor in the tube. By varying the composition of the fluorescent coating, the color of the glass, and the kind of gasses, an attractive range of colors may be obtained.

Fluorescent tubing provides a wider spectrum band of light output, with less power consumption, as compared with the usual type of gaseous tube which provides most of the light output in narrow visible bands.

Flourescent Lamps.—The new fluorescent lamps that have been made available introduce possibilities for applications and effects that may entirely change fields of illumination. A fluorescent lamp may be simply described as a slender glass tube, in various diameters and lengths, that glows with a rich bril-

liance when lighted. Standard lamps come in three lengths — eighteen inches, twenty-four inches and thirty-six inches; two diameters — one inch, and one and one-half inches.

The light that emanates from a fluorescent lamp consists of two parts, 1, a continuous spectrum from the activation of the fluorescent powders, and 2, a band of yellow, green, and blue light which results from the electrical discharge through the mercury vapor in the tube. This combination produces a light which is rich in the cooler colors. However, manufacturers have created a warmer shade of fluorescent light which is not intended to approximate the color of ordinary incandescent light, but rather to afford a more practical and economical approach to natural daylight.

Because of the many years of association with forms of illumination which produced warm reddish and yellow light it is not strange that man should find such odd difference in the effect of cool fluorescent light on his surroundings. The effects of this form of illumination are as different from incandescent lighting as the incandescent light is from natural daylight.

For interior illumination there are three types of fluorescent lamps available producing three shades of "white" light. These are: —

1. Daylight. A slightly bluish, cool light. It gives a light approximating that provided by a north window on an early spring day.
2. 3,000 deg. white. This is usually referred to as white. It slightly emphasizes greens and yellows. Because of its somewhat "warmer" color and its slightly higher light output it is more popular than the "daylight."
3. Soft white. The soft white lamp is considerably warmer than the other whites. It is a combination

of pink and daylight phosphors, and tends to emphasize the pinks and blues.

Fluorescent lamps are also manufactured in the following colors: — blue, green, pink, gold, and red, the color of the light being varied in the same way as in ordinary fluorescent tubes.

Except for the standard two-pin base and socket, a compact automatic cathode heating switch, and a built-in coil for controlling the current, no special equipment or wiring is needed for fluorescent lamps. They operate on either house current or from commercial power lines of higher voltage, and consume from fifteen to thirty watts apiece. Their surface brightness is very low, but their light output is exceedingly high.

Fluorescent lamps are equally effective in either direct or concealed lighting. In stores of any kind, these lamps in any of the seven colors, are unmatched. They create a good impression when used over merchandise shelves, or to attract attention to special niches, coves, or cases, and lend sparkle and salability to the goods on display. In banking rooms and conference chambers, where good seeing and unobtrusive lighting are important, daylight fluorescent lamps give glare-free illumination with ultramodern simplicity of appearance. When used for illuminating the interiors of modern residences, fluorescent lamps in various colors, harmonize perfectly, bringing advanced styling and good lighting into the home. They are especially effective in bedroom, bathroom, kitchen, dining room, and entrance hall. Theater lobbies and marquees, hotels, restaurants, railway stations, and industrial installations all offer an abundance of instances for the application of these lamps either for attraction or utility.

There is hardly a problem of illumination that cannot be effectively solved by the use of fluorescent

lamps. Wherever efficient artificial illumination or abundant colored light are required for better display, attraction, selling, and seeing, fluorescent lamps are practical, efficient and economical.

Color Changes Due to Fluorescent Lighting.—The effect of fluorescent light on wall colors, etc., is much different from the effect of incandescent illumination. Soft-white fluorescent light tends to bleach out and gray pastel shades, especially cool ones, but will flatter more saturated colors. Under the influence of the 3,000 deg. White lamp, cool colors have a tendency to grayness, while greens and yellows are intensified. The Daylight lamp will bleach out warm pastel colors. It also overemphasizes the cool blues.

Colors of Paints Tested	Appearance of Wall Colors			
	Incandescent	White Fluores Lamps (3500°)	Daylight Fluores. Lamps	Soft White Fluores. Lamps
BLUE (Pastel) (Bluish-green)	Yellowish faded blue	Grayish green	Bluish green	Slightly grayish
GREEN (Pastel) (Yellowish green)	Yellowish pale green	Yellowish green	Fresh blue green (pref.)	Slightly grayish
PEACH (Pastel)	Normal—same as white	Normal—slightly cold	Good—Slightly pink	Normal slightly pinkish
PINK (Pale)	Yellowish	Yellowish	Purplish Pink	Intensified normal pink
TAN (Pastel)	Strongly yellow	Yellowish	Grayish—cold	Cream—good
CREAM	Cream—good	Slightly greenish	Faded gray	Cream—good
DEEP CREAM	Yellowish—fair	Intensified—good	Bluish-excellent	Slightly grayed—good
RED	Yellowish—good	Yellowish—good	Slightly bluish—good	Warmer—good
DEEP BLUE	Grayed	Richer—good	Vivid—good	Vivid—blue preferred
ROSE	Yellowish	Yellowish	Bluish	Vivid—pref.
DEEP YELLOW	Reddish	Vivid	Grayish—unattractive	Slightly gray—good

The above table, which is the result of experiments conducted by O. P. Cleaver, of the Commercial and Engineering Department of the Westinghouse Lamp Division, Bloomfield, N. J., shows the effects of the three types of fluorescent light, as well as the familiar incandescent light, on well lighted wall surfaces painted in various colors. These facts are based on observations at levels of 25 to 50 foot-candles on test samples. An idea of the illumination represented by one foot-candle can be obtained by holding a piece of white paper one foot away in a horizontal direction from an ordinary lighted wax candle, or about five feet away from an ordinary 25 watt lamp. This range was considered as typical of the average levels used in the majority of present day applications.

Because the employment of fluorescent lamps in homes, beauty shoppes, night clubs, and funeral parlors, has become so wide-spread, the appearance of the human skin under the influence of this type of illumination needs consideration. Ordinary daylight lamps and whites are not very flattering to the skin, but the new Soft White fluorescent lamps have proved to be very satisfactory. Under the illumination from this lamp the various skins, untanned, and sunburned take on a natural, healthy glow that shows a decided improvement over other types of illumination.

The following table shows the general appearance of meats, fruits and vegetables under the influence of the three fluorescent whites as well as incandescent lamps: —

Test Article	Appearance			
	Daylight Mazda F	3500° White Mazda F	Soft White Mazda F	Filament (100 W.)
Red Meats	Poor	Fair	Good	Preferred
Dressed Chicken	Poor	Fair	Good	Good
Butter	Poor	Good	Good	Preferred
Chocolate	Poor	Fair	Fair	Good
Bread (Brown Crust)	Fair	Good	Good	Good
Oysters (Opened)	Poor	Poor	Fair	Preferred
Parsley	Good	Good	Fair	Poor
Carrots	Good	Good	Good	Good
Tomatoes	Fair	Fair	Fair	Preferred
Red Apples	Fair	Fair	Fair	Preferred
Onions	Poor	Fair	Fair	Fair
Green Apples	Good	Good	Fair	Poor
Squash	Fair	Good	Preferred	Good
Bananas	Fair	Good	Good	Good
Red and Green Pepper	Fair	Good	Good	Good
Green Beans	Good	Good	Fair	Fair
Cauliflower	Poor	Poor	Good	Good
Green Cabbage	Fair	Poor	Fair	Fair
Red Cabbage	Fair	Fair	Good	Preferred
Corn	Good	Preferred	Good	Good
Lemons	Poor	Poor	Fair	Good
Peaches	Good	Good	Good	Good
Oranges	Fair	Fair	Good	Preferred
Plums (Reddish Purple)	Fair	Good	Preferred	Good

Store Window Illumination.—Colored lighting in window displays has proved a great aid in attracting attention. The up-to-date merchant deems is essential that his store windows be "pepped up" with some such means in order to present his wares in a manner that will draw the interest of the passer-by. A well lighted

store window naturally commands interest and induces people to stop in their hurry along the street.

The illumination should be sufficiently high to offer marked contrast to the relatively low illumination of street lighting, but should in no wise be glaring. Glare is monotonous, garish and displeasing, and fails to accent the article on display more than the background. On the other hand, with relatively low illumination it is possible to produce unusual and spectacular effects by featuring the most important articles of merchandise in more intense, or colored, light. Very brilliant lighting should only be used on large displays intended to be viewed from a distance.

The direction of the lighting is also of importance. The general practice is to have the light come from above and in front of the articles on display. It is advisable to locate a few lamps at the bottom of the window, similar to stage footlights, as well as at the sides. The light from below should not generally exceed one-third that from above. All sources of light should be located out of the line of vision. Whatever method of illumination is used there should always be some cast shadow or the window display will lack perspective and present a flat appearance.

Where esthetics is not a deciding factor, unusually spectacular color effects may be made use of, but where consideration must be given to artistry and dignity more care needs to be exercised in the choice of suitably colored lights. The use of spotlights, either colored or white, is a factor worthy of consideration. This feature has been applied for many years on the Niagara Falls and still continues to attract thousands of sightseers every year.

Avoid extremes in store window illumination. Through the improper arrangement of colored light, distortion may easily be created. So it is that we find well thought out displays changing their entire ap-

pearance under artificial illumination. This factor can be governed to a surprising degree if more attention is given to both light and surface color. Colored light cast upon a surface of the same color changes such a surface color very little, except to add brightness to it. The greatest changes occur when light of a certain color is directed on to a surface having a different color. For example, orange light upon a green surface makes the latter appear dark yellow-green; upon a blue surface it gives a dark reddish cast; upon a violet surface it shows a dark purplish-gray; and upon a black surface it appears brownish-black. Yellow light upon a blue surface makes it appear as greenish neutral, and upon black it gives olive-toned black. Green light upon a red surface appears as yellowish-green and on a violet surface it shows as greenish-gray.

With the aid of the chart on Plate 7, and with a little personal experimenting, many interesting changes brought about through the action of light of various colors on different colored surfaces may be discovered. While the statements presented in the table are of infinite value in themselves, still much depends upon the color properties presented by both light and surface. The quantity, as well as the quality, of each has an influence on the resulting effect. The intensity and character of neighboring illumination must also be taken into consideration. So each installation offers problems peculiar to itself which can only be successfully solved when all circumstances are understood.

Stage Lighting.—Lighting has an important bearing on the success and effectiveness of everything that is produced on a stage. It is the only single agency that can bind together the scenery, costuming, and make-up, and can "act" with the actors. Its main purposes are:

1. To illuminate the stage and the actors.
2. To help in adjusting the color values of the scenery in relation to other things, by adding light and shade.
3. To suggest natural light effects, and thus intimate by association the hour of the day, the season, or the weather.
4. To make the acting more effective by symbolizing its meaning and giving added force to its psychology.

The greatest problem of stage lighting is that of control. This is a very intricate subject that is beyond the scope of this work. The switchboard may be said to be the "nerve center" of the stage lighting system. Cables and wires run from all the lighting units to the switchboard, which is a complicated arrangement of switches and dimmers. As has been stated previously, dimmers are devices for controlling the electric current through rheostats so that more or less current reaches the lamps, which thereupon grow brighter or dimmer. There are so many steps to a dimmer that the lights can be made to change almost imperceptibly from their maximum to their minimum brightness, or vice versa. The ideal situation is to have every light, or failing this, every circuit, on a dimmer. In this way it is possible to represent the whole sequence of a day's light effects. The dawn of day might be suggested with blue and white lights, then, by gradually lessening the blue and raising the red lights, and again lessening the red and increasing the white and some yellow, the cool light of the morn asserts itself. Yellow light may now be given full sway to represent afternoon sunlight flooding the scene, which in the late afternoon gradually fades through red to the blue and white of twilight. This grows deeper and deeper until it engulfs the scene, symbolizing the darkness of night.

Stage lighting units should be controlled either to offset, or else to re-inforce, one another. In other words, they should be balanced. To illustrate, suppose the stage is set to represent a drawing room furnished with usual pieces — chairs, couches, cabinets, etc., and all the actors in their respective places. If the footlights and auditorium lights only were directed on the scene all light would be coming from the front, hence all objects and persons on the stage would cast dark shadows back along the floor or on the back wall of the room. However, if the same amount of light as from the front is directed on from overhead lights and sidelights, the shadows may be made to disappear.

Lighting a scene in a play is a very painstaking operation. It cannot be decided in the abstract. The designer, or the stage director, usually decides on the effect desired. He takes his place somewhere in the auditorium and directs the different units — turning lights off here and on there, bringing the light intensities up or down, and varying the colors until he is satisfied with the result. The actors, or their substitutes, should be in their places during this procedure, as one of the things that requires utmost attention is the way the light falls upon the faces of the people on the stage. Care must be exercised as to how the shadows fall, and how they change as the actors move about.

In order to change the color of the light a colored gelatin is slipped in a lamp. The colors most used for this purpose are red, blue, green, amber and yellow. With these, either singly or in combination, almost any effect can be produced. The footlights usually consist of red, blue, yellow and white lamps arranged in series in the abovementioned order all the way across the front of the stage. Each color is individually controlled from the switchboard.

Scenes should not be flooded with white garish light, neither should brilliant or vividly colored light be used, unless for special effects. Such effects should be very infrequent, and only be used in such instances as are necessary to give a certain psychological stimulus.

A colored surface is brightest under light of the same color. Warm colored lights intensify warm colors in costumes and scenery, and make cool colors seem duller. On the other hand, cool colors are intensified under cool colored light. A colored light on a surface which is complementary in color to the light, neutralizes the color of the surface. Such colored lights as straw, lemon, light blue, and other tints, produce less color changes in objects than do the more vivid and brilliant lights.

A set may be lighted with a certain color and by throwing on to it different colored light, an entirely different effect may be produced. For example, suppose a scene on a stage was painted to represent an autumn landscape. The foliage would probably be in tones of reddish-brown, orange and tan. The trunks and branches of the trees, as well as the portions in shadow, would be in blue-green, blue, violet and very dark dull brown. To effectively illuminate this scene yellow and white lights would be used. Now, if these lights were extinguished and the whole set flooded with red light, the autumn effect would instantly change into a winter snow scene. The red and orange tone would appear as blankets of snow. The reason for this change of effect is because the reds and oranges as well as the tans are in harmony with the red light and cannot be identified, while the blue-green, blue, violet and neutral tones of the tree trunks, branches, and shadows, because they are complementary to the red light, appear as grays of different tones.

Experimentation with colored lights, separate or in combination, on a variety of surfaces and textures,

should convince one of the wonderful, unfulfilled possibilities of the glorious element — light.

Trapping Insects With Lights.—The trapping of insects by means of lights is part of the relentless warfare against many types of bugs. It was largely through the miniature golf craze that came upon us some years ago that this method of trapping insects came into use. During night games it was necessary to have bright lights to illuminate the course. The lights attracted bugs, and the bugs annoyed patrons. For this reason light traps were introduced to attract and catch the pests.

One of the simplest of these traps consists of a lighted lamp placed above a can of kerosene or beside specially prepared sticky leaves or strips of sticky flypaper. Sooner or later, the bugs fly to the light and eventually skid down into the kerosene or against the sticky leaves or flypaper.

Many night-flying insects are attracted to bluish-white light. Bees, hornets, and wasps are blind to red and green lights, and perceive only yellow and blue. In fact, red and green lights have little attraction since most insects seem to be blind to them. Blue-violet light bordering on the edge of the visible spectrum, and near-ultraviolet ranging from the edge of the visible spectrum and to about 330 millimicrons, have been found to be the most effective for trapping.

CHAPTER ELEVEN

THE MIRACLES OF LIGHT

Electromagnetic Spectrum. — In the undulatory theory of light there is supposed to exist a hypothetical material called "ether," which fills all space and permeates the molecules and atoms of all matter. In it, disturbances may be set up which are propagated in the form of waves or vibrations. These waves travel at a constant speed of 186,780 miles per second. However, they may differ in their length and in the number per unit of time.

For specifying the length of these waves certain units of measurement have been adopted. The unit of measurement used in most scientific laboratories is the "meter." One meter equals 39.37 inches. For general use the meter meets most needs, but in connection with electromagnetic vibrations it is not entirely satisfactory. It may be perfectly adapted to specifying the length of radio waves, but when used to specify very short vibrations it brings into play an unwieldly series of numerals. Because of this, other units of measurement stated in terms of the millimeter or some fraction thereof are employed, thus:

1 Micron = 1/1,000 of a millimeter
1 Millimicron = 1/1,000,000 of a millimeter
1 Angstrom unit = 1/10,000,000 of a millimeter

Of the entire gamut of vibrations in the electromagnetic spectrum the average eye responds to only a very limited region, extending from about 400 millimicrons to about 700 millimicrons. This is the visible spectrum, and it corresponds with the array of colors in the solar spectrum — the rainbow. An examination of the solar spectrum will disclose the fact that though

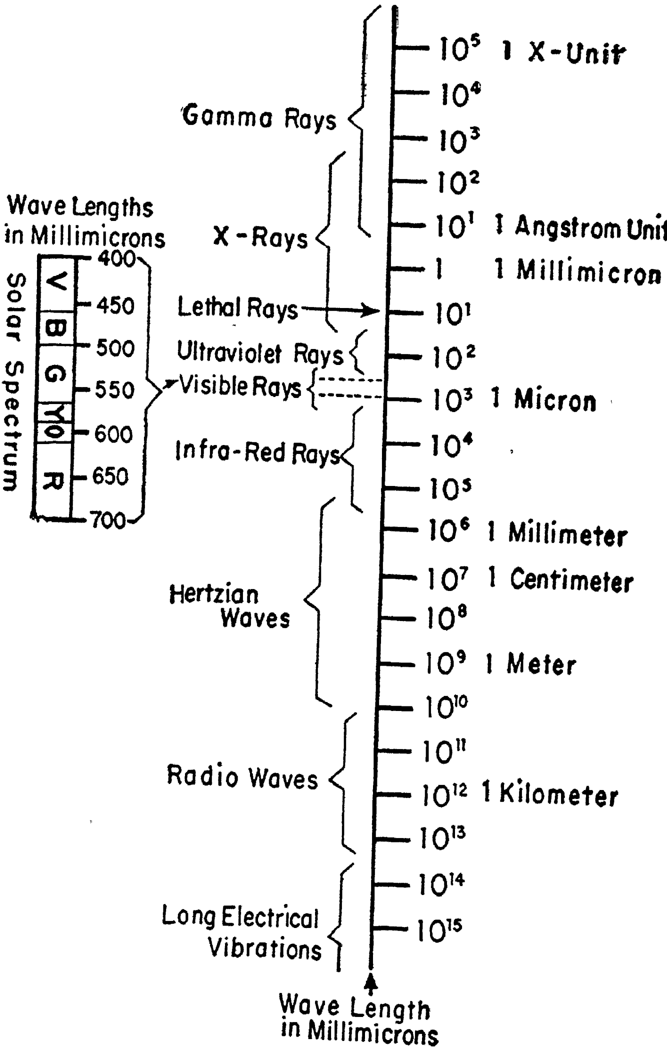
Wave Lengths
in Millimicrons
Solar Spectrum
V
B
G
Y
O
R
400
450
500
550
600
650
700
Gamma Rays
X-Rays
Lethal Rays
Ultraviolet Rays
Visible Rays
Infra-Red Rays
Hertzian Waves
Radio Waves
Long Electrical Vibrations
10⁵ 1 X-Unit
10⁴
10³
10²
10¹ 1 Angstrom Unit
1 1 Millimicron
10¹
10²
10³ 1 Micron
10⁴
10⁵
10⁶ 1 Millimeter
10⁷ 1 Centimeter
10⁸
10⁹ 1 Meter
10¹⁰
10¹¹
10¹² 1 Kilometer
10¹³
10¹⁴
10¹⁵
Wave Length
in Millimicrons

PLATE 8

its hue appearance varies in a continuous gradation throughout its entire length it is possible to divide it into six dominant hue regions. These are violet, blue, green, yellow, orange, and red. The approximate range of each is as follows:

Violet	extends from 400 to 460 millimicrons
Blue	extends from 460 to 500 millimicrons
Green	extends from 500 to 570 millimicrons
Yellow	extends from 570 to 590 millimicrons
Orange	extends from 590 to 610 millimicrons
Red	extends from 610 to 700 millimicrons

Waves that are longer than 700 millimicrons pass out of the range of visibility into the region of infra-red rays. These are heat rays. Continuing from the infra-red rays we pass to the longer Hertzian waves and radio waves.

Moving to waves shorter than 400 millimicrons we enter the region of the invisible ultraviolet rays. Beyond these are the shorter X, or Roentgen, rays, and the very short gamma rays. Ultraviolet radiation may be divided into three ranges as follows:

1. "Near" ultraviolet light is just beyond the violet in the visible spectrum. This is the range of "black light," so-called because the radiation is not discernible as light. It is not harmful to eyes or skin.
2. "Middle" ultraviolet, which is useful for sun-tan and health purposes. Over exposure of the eyes and skin to these rays should be avoided.
3. "Far" ultraviolet, bordering on the X rays, is the location of the more recently segregated lethal, or "death," rays. They are useful for sterilization purposes but are very harmful to the skin and eyes unless proper precautionary measures are taken.

A chart of the entire electromagnetic spectrum is shown on Plate 8.

Ultraviolet Light and Fluorescence.—It is not possible for the human eye to see ultraviolet light, yet its radiations are absorbed by a wide range of substances and instantly re-emitted in the form of visible light of constant intensity. These substances act in a sense as light transformers, since they change unseen ultraviolet light to visible colored light by changing the wave lengths of the radiations absorbed from the ultra-ultraviolet source and re-emitting this transformed energy in wave lengths which the eye registers as colored light. Such substances are said to be "fluorescent."

Many household goods possess the quality of flourescence. Ordinary machine oil and petroleum jelly exposed in a darkened room to ultraviolet light have a blue glow. Some sealing waxes fluoresce a brilliant color, while others, apparently the same under ordinary light, fluoresce a deep pink under the influence of ultraviolet light. Calomel, or mercurous chloride, in solid form will fluoresce with a peculiar orange-gold glow when subjected to ultraviolet radiation.

Under ultraviolet light, many dyes exhibit fluorescent properties. A solution of uranin in water will show a yellowish light. An alcoholic solution of rhodamine will glow red. Anthracene, a coal tar product, glows a vivid yellowish-green color. When anthracene is dissolved in benzine, gasoline, or xylene, it makes an invisible ink. A message written with this ink will be invisible in ordinary light, but when exposed to ultraviolet light will glow with letters like fire. A few other substances and the colors they fluoresce under ultraviolet light are; — calcite, red; barium sulphide, orange; fluorescein and oesin, yellow; cadmium compounds, yellow; uranium glass, greenish-yellow; some salts of salicylic acid, blue; calcium sulphide and some other compounds of calcium, violet; calcium tungstate, light blue; zinc sili-

cate, green. A variety of other colors may be obtained by the mixture of some of these substances.

There are available various sources of ultraviolet radiation, or "black light." Manufacturers of black light equipment have developed many new types of flood and spot light units for either large or small installations. A source of black light, which is fairly low costing, yet efficient and powerful, is a portable black quartz lamp. Cooper-Hewitt lamps enclosed in specially made deep purple glass tubes that hold back all visible light and allow only concentrated rays of invisible ultraviolet light to pass through, form another source of this energy. For very small installations, 2.5 watt argon lamps, which may be obtained from any large electrical supply store at low cost, may be used. Other sources of this light are constantly being developed according to demand.

Painting With "Canned Light."—As a decorative feature, black light and fluorescent materials have been employed very effectively in many of the interiors of modern theaters and public buildings. Not only has this technique been used as a medium for producing unusual decorative effects, but also as an ideal method of illuminating certain locations which require very low lighting levels.

Fiction writers and others of imaginative ability have often written of the future day when illumination of interiors would be ideally provided by luminous walls and ceilings capable of emitting the necessary light. This day has now arrived, and the first few major installations completed have been judged highly successful and important as an indication of future trends.

Regarding the decorative illumination of interiors through the use of fluorescent materials and ultraviolet light we will quote, by permission, a couple of paragraphs from an article written by Mr. John T.

Shannon, of the Keese Engineering Company, Hollywood, California, for "Better Theaters" magazine:—

"Least used to date of all its possibilities is the power of black light to provide ordinary utility illumination. Carpets impregnated with fluorescent substances and lighted by invisible sources have very recently come into use. Walls and ceilings similarly treated and lighted have been made to provide illumination for the auditorium or for the area surrounding the screen, or both. If the walls are painted in complementary colors, in small and adjoining areas, the light emanating from these walls will mix a short distance away from them and produce the effect of white fluorescent light.

"The fluorescent substances or paints — "canned light," for that is what they are, can be obtained in a great variety of colors, duplicating almost all the normally visible colors, and these in turn can be made to produce blended illumination effects by applying two or more of them near each other on the same surface. Disregarding the color with which they glow under ultraviolet excitation, these substances or paints are of two general types, opaque and transparent. The transparent type, painted over ordinary colors, is invisible when viewed by natural light, but when the same surface is illuminated with black light only, the underlying ordinary natural color is lost and only the fluorescence of the transparent layer can be seen—the color of the fluorescence having no necessary relation to the color of the underlying surface. Thus, by using a transparent lacquer and substituting ultraviolet for natural lighting, and vice versa, the appearance of the surface is changed at will. Using both forms of light simultaneously gives a three-dimensional illusion. Opaque fluorescent lacquer enamels, eliminating the need for an underpainting of ordinary materials, are also available."

Walls and ceilings coated with fluorescent paints are depended upon as the source of running illumination in numerous recent theater auditorium installations. In one new Hollywood theater, for example, virtually every square foot of ceiling and walls is fluorescent. Sunlight and moonlight effects, produced with blue and flame-tinted incandescent lamps, provide intermission lighting, otherwise there are no lights, fixtures, or sidewall brackets. During the presentation, the patron is seated beneath the most beautiful deeply luminous blue Hawaiian night sky with brightly glowing stars. Because of the perfect third-dimensional effects obtainable by this technique, the sidewalls appear to have receded, and a fluorescent rendition of Mount Manua Loa spouting fire and smoke gives the appearance that it is many miles in the distance. Light emitted by the over-all fluorescent treatment bathes the auditorium with shadowless moonlight providing excellent illumination without screen interference and without a single glaring light source or brilliantly lighted surface.

Now, "painting with light" is a reality. As simple to apply as ordinary colored paints they open fields having tremendous potentialities in the decoration and illumination of theater and other auditoriums, night clubs, ballrooms, and other locations where low levels of illumination are desired without glare from visible light sources.

Black light equipment and fluorescent paints, the most modern tools of the decorative lighting specialist, form the ideal means of theater auditorium lighting. No more will the patron have to reach into someone's lap, or heel someone's shins, getting into a seat.

Flourescent materials have also found wide application in stage presentations, advertising set-ups, and window displays.

Fluorescence and Luminescence.—The difference between fluorescent materials and luminescent materials is primarily one of length of afterglow, that is, the length of time they continue to glow after activation by the light that excites them has ceased. Fluorescent materials generally cease emitting light as soon as the activating source of energy has been removed, although in some instances the glow may actually continue for a very short time. Luminescent materials, on the other hand, possess an afterglow which may persist for a few hours to a complete night. There are two types of luminescent materials, (1) the phosphorescent type which requires external stimulation, or activation, by light, and (2) the radioactive type which is self activated by small amounts of radioactive elements within itself.

Luminescent Paints.—These are almost exclusively phosphorescent in character. They are relatively cheap to manufacture and are mostly non-poisonous. The luminous pigments employed in their make-up consist of specially prepared sulphides of calcium, strontium, barium, and zinc. Traces of copper, bismuth, lead, cadmium, manganese, samarium, cobalt, and nickel in the paint influence the afterglow and color to a considerable extent. Luminous strontium sulphide has a greenish afterglow, calcium sulphide a violet afterglow, and zinc sulphide a yellowish-green afterglow.

The calcium and strontium types of luminous paints have a relatively low initial brightness but have an afterglow of from two to twelve hours. Zinc sulphides have a high initial brightness but a much shorter afterglow of two hours or less. The type which would be used in a given situation is dependent upon the service expected.

Luminous paints have proved a valuable aid in furnishing illumination of a kind during blackouts in

time of war. The light radiated from such materials is of no aid to an enemy as it is invisible to airplanes flying overhead. In protecting defense plants and civilians during blackouts it serves a useful purpose in the marking of street curbs and intersections, emergency apparatus, exits, directions and danger signs, etc. It is of special value on shipboard, and for illumination on life rafts, lifeboats and preservers.

When used on a sign it has been found best to use the luminous paint for the background rather than for the lettering. Coated flexible fabrics are now available already treated with luminous materials. These need only cutting to size and shape for instant use. Black letters can readily be painted on these surfaces. Paper, cardboard, and even decalcomania transfers are now available coated with luminous paints and inks.

In contrast to phosphorescent luminous paints, which are nonpoisonous, radioactive luminous paints are very poisonous and are not recommended for use by anyone unfamiliar with the precautions necessary for their safe use. They have been in use for years for numerals on clock dials, compasses, etc. The luminous material is usually zinc sulphide activated by a radio active element. Radioactive luminous paints do not require any activation by any light source.

Mysteries of Infra-Red.—Infra-red rays are those that lie immediately next to the red in the visible spectrum. They are invisible to the human eye. They are long in wave length and are powerful in penetrating mist and fog, whereas the short blue, violet, and ultraviolet rays are easily split up by atmosphere. An infra-red equipped camera is sensitive to penetrating infra-red rays and will photograph objects and distances which to the normal eye and the ordinary camera might be unintelligible.

Infra-red photography has proved to be of immense

military value. Detection of camouflage, depending to some extent on visual observation, finds its greatest aid in infra-red photography aloft. Two colors which appear the same to the human eye, or which reveal the same shade of gray when photographed on ordinary film, may appear entirely different when photographed on infra-red sensitive film. A military installation blended or camouflaged into the surrounding terrain by the artful use of ordinary green paint, although quite effective to the human vision and to the ordinary camera, would not escape detection by the infra-red equipped camera. The green chlorophyll of nature, found in grass, leaves, etc., has the quality of reflecting infra-red rays effectively, and due to this characteristic, it will photograph bright in tone in an infra-red photograph. On the other hand, ordinary green paints used to simulate nature may photograph black, or almost black, despite the fact that the actual area and the camouflaged area may appear quite alike to the human eye and in an ordinary photograph.

Now, however, the camoufleur has overcome this obstacle. Paints have been formulated which not only visibly match the surrounding natural greens, but are as high in infra-red reflectance, and are thus able to fool the infra-red camera and the eye.

Besides green, other colors such as olive drab, field drab, loam black, earth red, brown and yellow, have been developed which are as effective under infra-red photography as they are visually.

Infra-Red Radiation in Industry.—The use of banks of infra-red lamps in front of gold plated or copper plated reflectors for producing heat to bake industrial finishes is one of the most recent developments.

In order to concentrate the infra-red energy on to a definite area, special parabolic reflectors are used. The concentration of the radiation falling on the work is of great importance. Experiments have shown that

with a concentration of 1.2 watts per square inch upon the surface to be baked, a temperature of 200 degrees Fahrenheit may be reached in five minutes. With a concentration of 6 watts per square inch on the same surface, a temperature of 500 degrees Fahrenheit may be reached in the same time.

Thousands of infra-red lamps are installed in the River Rouge plant of the Ford Motor Company for the drying and baking of Ford synthetic enamel. The lamps are arranged in tunnels, and the automobile bodies travel through these tunnels on overhead conveyors. This method of drying is so efficient that the primer coat, which formerly required one hour when other types of ovens were used, may now be dried in fifteen minutes.

Infra-red radiation has no magical powers, but it does provide a very effective way of getting heat into a paint film. According to the engineers who developed this method of drying paints and other similar coatings, the finish dries "from inside out." The infra-red rays penetrate the coating and heat the metal underneath so that the paint film dries as rapidly from the inside as from the outside.

Infra-red radiation obeys the laws of light as to reflection and radiation. It therefore may be expected that blacks heat more quickly than whites. For example, a white-painted surface was observed to reach a temperature of 275 degrees Fahrenheit in 15 minutes, while a similar surface painted black reached a temperature of 350 degrees Fahrenheit in the same time. A metal sheet painted white on one side only will be baked better and in a shorter time by exposing the unpainted side to the rays. If one side is painted black and the other white, both coatings will best be baked by exposing the black side to the rays.

The use of infra-red radiation for drying and baking processes is as yet in its infancy, but its application to

industrial finishing is spreading rapidly.

Lethal, or "Death" Rays.—One of the most thrilling aspects of the "miracles" of light is the use of the lethal ray as a potential and powerful agency of destruction on bacteria and harmful micro-organisms. Some kinds of bacteria are helpful and indispensable to human beings. It is the harmful kind such as decay and mold organisms, disease germs that pillage human health, and organisms of infection that endanger wounds and surgical operations. No matter how much care is exercised, harmful bacteria sometimes get through into an open wound. Ordinary flesh wounds may be pretty well cleansed with suitable liquid or other sterilizers, but this cannot be done to "germ-proof" a large wound in a major operation. There has recently been developed a device whereby every kind of wound can be cleansed of all harmful bacteria by means of lethal rays. In addition to this, lethal rays are used to combat certain skin diseases such as ring-worm and athlete's foot.

Lethal ray equipment is now being used extensively by hotels and restaurants to kill every kind of organism that may lurk on cutlery, plates, dishes, cups, glasses, etc. Commercial packers and canners are adopting the lethal way to sterilize and ensure the keeping qualities of their products.

Light and Growth. — In viewing the miracles of light we should take into consideration the relation between light, life, and leaf. In this trinity lies the source of the food we eat, the clothes we wear, the wood which builds our houses, the coal with which we keep our homes warm and which is used to generate steam for the operation of engines, and the gasoline and oil used to propel vehicles.

Light, usually sunlight, is the basic growth element for plants. The earlier theory, however, that only sunlight can cause a seed to sprout is now in discard.

Some nurserymen have found that if sunlight is supplemented by a few hours electrical illumination at night it will work wonders, causing many plants to bloom or mature several weeks sooner than they otherwise would. In fact, there are some who believe that plant growth is actually affected by moonlight. Dr. Randall R. Kincaid, scientific director of the Florida State Experiment, has proved that a small seed, such as a tobacco seed, will actually germinate when exposed to bright moonlight only. All light seems to have some bearing in its effect upon living organisms, and since sunlight is free and universal and electrical facilities are almost unlimited, the possibility of man's being able to control or influence plant life by means of light is of great importance.

A test was made by a group of scientists to determine the effects of the ultraviolet, the visible, and the infra-red portions of the spectrum on the growth of plants. There were eight plants used in the experiments. All seeds were planted at the same time and under identical conditions except for the quantity and quality of the radiant energy. Two of them were subjected to ultraviolet and violet light and grew the tallest, being almost equal in height. Next to these, in respective order down to the smallest, came one grown under infra-red radiation, one grown under blue light, one that received ordinary sunlight, one grown under green light, one grown under yellow light, and the smallest of all was the one grown under red illumination.

Lifegiving Green.—Green plants control the food and fuel supply and the life of the whole animal kingdom. Energy from sunlight is stored in them through the aid of the green coloring, or chlorophyll, of the leaves. Below the upper epidermis of green leaves is a layer of regular cells which are arranged like the boards of a fence. Each of these cells contains a living proto-

plasm in which are numerous bodies called "chloroplasts" which hold the green chlorophyll as a sponge holds water. When sunshine strikes the chlorophyll and is filtered through it, it acts upon the carbon dioxide, water, and mineral salts, which the plant has obtained from the air and the soil, to form carbohydrates — sugars. Carbohydrates are included in most of our common foods which supply heat and energy. Human beings, as children of the sun, are very dependent upon the energy stored in food plants.

Green leaves may be called the factories where carbohydrates and proteins are made. A leaf when tested in the early morning, before it has received much sunlight, is practically without starch and other carbohydrates, but after exposure to sunlight even for only one hour will be found, on testing, to have produced much starch and sugar. Sugar is one of the first carbohydrates to be produced, and this sugary solution is carried through various conduits to the living cells in the plant.

The sugar in the sugar cane, in beetroot, in corn, in wheat, and in potatoes, is all made primarily because the green chlorophyll, which gives most plants and leaves their characteristic coloring, is the greatest known trapper of sunshine. The chlorophyll accomplishes much because it is used again and again without any change in its composition and amount. It is actually a catalyst—it promotes changes but is itself not affected by these changes.

Autumn Leaf Colors.—Now that we have considered what makes plants green, and the purpose of chlorophyll, let us answer the question: "Whence comes the glory of the autumnal coloring of leaves and plants?" Science has the answer. Natural chemical reactions within the leaves of plants and trees, rather than autumn frosts, cause the brilliant reds, yellows, and browns to replace the green. Frosts hasten but do not

cause the change. Part of the coloring is there all the time, but is covered and masked by the all-dominating green — the chlorophyll. The changes in light and temperature in the autumn cause the chlorophyll to die and disintegrate. It is then that the aging leaves permit the gorgeous colors to appear. In addition, certain sugars and acids set up a chemical reaction which produces the reds of maples, sumacs, oaks, and some varieties of plants including the woodbine.

The colors which appear in leaves during the autumn season come mainly from three types of pigments. The red and purplish tones are due to a substance called "anthocyanin" — the same pigment that gives the red color to beets, red cabbage, and most deep red flowers. Anthocyanin forms in the presence of sugar, especially when the temperature is low. It is only produced in the presence of strong light. Therefore, a tree may have red leaves on one side and not on another. The reds are more intense after a summer of long, sunny days. The yellows are present in the leaves all the time, and probably have some function in the food cycle within them not as yet understood. Not until the chlorophyll dies and loses its color can the yellow shine forth in all their beauty. Two pigments called "xanthophyll" and "carotin" are responsible for the yellow coloring. Carotin is abundant in carrots, hence its name.

Sudden hard frosts often kill the leaves and their pigments outright, turning them to a dull, dead brown. It is for this reason that a gradual change of season is necessary for the full development of the colors. In parts of the country where frosts come early and gradual after a summer of brilliant sunshine, the gorgeous reds, yellows, and golden browns cover the landscape with a color pattern that is the despair of artists and an unforgettable memory to those fortunate enough to have beheld it.

CHAPTER TWELVE

COLOR IN HOME DECORATION

Color! We all want color. It is one of the most vital influences in harmonious living. Life without color would be drab indeed. America today is fresher — gayer — more alive than ever before because of the influence of color. Whether expressed on commodities for sale, in nature, pictures, fabrics, furniture, or wall decoration, its appeal is universal. To appreciate and use color is to live!

Nothing under the sun seems really new in the way of color itself. It is the difference in its presentation and usage that produces new aspects. Exquisite and improved ideas in its employment make yesterday's color "modern" today.

Color fashions in home decoration change periodically just as in clothes. Some thirty years ago the prevailing idea was that furniture and accessories in a room should have a neutral background. This was a radical change from the bright colors in which people previously to that time had been revelling. It was at this period that the neutral color known as taupe took the place of the bright happy colors that were loved. It became a world of taupe — taupe rugs, taupe-covered furniture, and even tones of taupe on walls.

Men and women soon tired of this idea of neutrality. They began to surround themselves again with cheerful color. A new fashion "came out." At this time the popular "pastel shades," which so beautifully serve as quietly colorful backgrounds for furnishings, came into vogue.

Color in Interior Decoration.—The woman is the one who usually has most to say about the interior management of the home. Above all things, it is the desire of her heart to make it as charming and attractive as possible to her family and friends.

Sometimes milady longs to own a room that she has seen pictured in a magazine or displayed in a store — a room full of charm and character. How she desires that room! She is, however, at a loss to know how to plan and where to start when it comes to putting her dreams into actual reality. She may select colors at random, without much thought about their appropriateness, using only vague "personal taste" to guide her, and often failing to get the pleasing and harmonious effect that was so greatly desired.

The mere selection of a group of harmonious colors is not enough. Any consideration of ideas concerning the choice and distribution of colors in a room ought to be preceded by a study of conditions and problems which the room presents.

The dominant color effect may be selected because of the personal preference for that color. It may be chosen because of its power to make a room appear smaller or larger, higher or lower, or because there are already in the room certain fixed colors such as on trim, furniture, rugs, etc. The light a room receives needs also to be taken into consideration.

Room exposure.—The exposure of a room, or the quality of light it receives, plays a rather important part in determining the color tone to be used. Rooms exposed to the north or shady side are usually most pleasing when finished in warm colors, such as cream, canary yellow, peach, pink, buff, rose, cameo, etc. Colors such as light blue, peacock blue, robin's egg blue, pea green, sea-green and light nile green are cool colors and should be used for warm, sunny southern exposures. Rooms with east or northeast exposures need

warm colors, while those with west or southwest exposures take cool colors to best advantage. A balance of warm and cool tones is suggested for rooms of uncertain light as, for example, where east light conflicts with west light. A balanced color scheme in such a situation might have wall areas in warm peach, ceiling in white or ivory, cool turquoise blue drapes and upholstery, and blue-green rug, thus making fairly equal use of both warm and cool tones.

The amount of natural light available needs consideration in the selection of colors. If the room is shaded or the light from the windows is inadequate for the size of the room, light colors should be given preference. If the room has an abundance of light, darker colors may be selected.

Camouflage in Interior Decoration. — Color may create certain illusions which may be used effectively to camouflage certain undesirable architectural features in a room. Light colors tend to make a room appear larger. Dark colors make rooms seem smaller. A dark ceiling apparently lowers the height of a room, whereas a light ceiling increases the height. Vertical stripes on side walls make a ceiling appear higher, and horizontal stripes help make a too high room seem lower.

A room which appears small and cramped may be made to appear larger by the use of the same color on walls, ceilings and trim. Light cool colors will further emphasize this effect because they are receding colors. The use of a darker color on the end walls of a long narrow room will cause it to appear shorter and wider. Warm colors such as peach, apricot and pink, are advancing colors. They apparently bring the walls forward and are very useful when it is desired to make a large room appear smaller.

It must be remembered, however, that rules in the use of color in interior decoration are flexible. The

qualified colorist, besides knowing the principles of when and where to use colors on the architectural surfaces of homes, is also competent to take the liberty of casting aside certain rules and substituting treatments more interesting, more artistic and more daring.

Color Suggestions.—It is well before adopting a color scheme to consider which are the most appropriate tones for the character of the room.

The entrance hall may be formal and polite, or gay and charming, but it should always be simple and free from affectation, both in color and furnishings. It is here where the guest is welcomed. Colors, therefore, that suggest warmth are best.

An air of livableness and charm should be the keynote of the living room. Quiet colors are best, as these will most readily lend themselves to the moods of the different members of the family, and will always be appreciated by the friends who are entertained there. The popularly known pastel shades provide good backgrounds for most furniture. Pastel tones of green, deep pink, peach, mustard yellow and lavender-toned gray are very effective. Off-white trim is always good with such colors, as is trim having the same color as the walls or slightly darker.

Scientists tell us that color aids conversation and digestion. It should therefore be made to contribute its share to the happy and peaceful setting that makes the family dinner a congenial and enjoyable feast. The days of somber mahogany and brooding browns are gone. No longer does the chandelier hang like Damocles' sword overhead. Today, color schemes are cheerier and more inviting. Such tones as blossom pink, light tan, canary yellow, cream, pale jade, warm beige and Wedgewood blue spread sunshine in the modern dining room.

The culinary director — the woman of the house, spends much of her time in the kitchen. It is her

domain. Make it a fit place for a queen. Here color may be at its brightest, walls and trim their glistening best. Suitable colors for the up-to-date kitchen seem to be without limit. Pale tones as well as strong full colors find an equal place and may be used to accommodate any mood.

Bedroom may express the personality of the occupant — reposeful or gay, dainty or vigorous. With soft, velvety tones, a bedroom may be made lighthearted and buoyant, or calm and formal, to suit the whims and temperament of the individual. While soft pastel colors are always successful for bedrooms, grayed tones which make any color a soft and satisfying one are very pleasing. Such colors may be cornflower blue, periwinkle blue, old rose and bisque, the latter a warm gray with an orange base. Other popular colors are turquoise, peach, aqua-green and soft tan. The trim may be in lighter or darker tones of the same rather than white, which is rather too insistent for a restful bedroom theme.

That combined barber shop, beauty parlor and first aid station — the bathroom, can be made fresh and clean with proper color. Soft pale tones, bright tints, deep marine colors, in fact almost any hue may be used here. Do not combine several heavy colors, but use them in small areas only to add interest and contrast. Wisteria, apricot, lettuce green, rose pink, canary yellow, sky blue, peach, delphinium blue, ivory and cream are used in today's invigorating color schemes.

Choosing Colors According to Personality Types.— Now comes the modern, somewhat intriguing, idea of choosing colors for room walls according to the complexion type of the room's occupant. This new idea is having a good deal of publicity at the present. Furniture manufacturers, paint makers, and exhibition rooms in stores are showing color schemes in relation to brunettes, blonds and others. In these new ideas

consideration is also given to the personality and wearing apparel.

Broadly speaking, women are divided into five types; —blond, brunette, red haired, gray, and what is generally called the All-American type. Advice regarding the wall colors that enhance certain types is of course somewhat general. For example, there are several degrees of blondness, including platinum, the very light almost silvery hair, the light yellow, straw, and the medium light brown.

Wall colors suitable for blonds may be fairly dark shades of any color, medium tones tending toward dark, or delicate pastel tones. Strong unrestrained colors, such as rich dark reds, blues and browns, as well as full-toned yellows should be avoided as they make light blond hair appear weak in tone. Light turquoise on the walls set off most blonds to great advantage. Pale pink, ashes of roses (a medium light rose color with a yellowish cast), light jade green, and pale coffee brown are all recommended.

Brunettes are pictured to advantage against strong definite tones. They should avoid dark and medium tones as these do not afford enough contrast to the rich dark brown or black hair. Like the blond, the brunette may use the very lightest tints of practically any color. Pale tones of rose, green, blue and light yellow are appropriate colors for the room walls to set off a brunette to advantages. A flattering room treatment for a brunette might be pale rose on three of the walls and very pale grayish blue on the fourth wall and the ceiling.

The red haired, or auburn, type are advised to keep their surroundings in either dark tones or light pastel tints, and must avoid definite, rich, colors as they compete too strongly with her vivid hair color. A suggested color combination for the red head is very pale

green and white — the green for the walls and white for ceiling.

The woman with silvery gray hair may enhance its attractiveness by choosing a middle range of rich tones, avoiding pastels and neutrals. Warm brown, red or green are complimentary for persons with silvery gray hair. Strong rose tones and definite light blue are very effective.

The fifth type is the "All American." Her hair is medium brown. Because her coloring is neither too strong nor too delicate she may use bright but not excessively deep colors. Pastels and pale clear tints may also be her choice. The All American type should avoid neutral tones as these tend to make the complexion look sallow. Colonial Old Rose, made by mixing together 40 parts of white, 2 parts of bright red, 2 parts of burnt umber and one part raw sienna, used on the walls, with old ivory on the ceiling, make an attractive background for this type.

A woman's personality usually influences her in her choice of dress colors. Because of her interest in color she often desires to have the wall colors of the room she occupies harmonize with the color of her gown as well as her hair. Since she chooses her dresses to harmonize with her complexion it naturally follows that colors keyed to the dresses she wears are bound to give her hair a flattering background.

In all these suggestions regarding color schemes to match personality types the question arises as to how these special treatments affect other members of the family and visitors. Generally, interiors arranged so that the room furnishings harmonize with the wall colors may be counted upon to be agreeable to almost anyone.

Color for Home Exteriors. — Color, properly distributed, can bring out the best design lines on the exterior of the home. Big, cold, clumsy-looking houses

are made to look smaller and neater; small houses made to look more spacious; houses that are angular and ungainly made more symmetrical; tall, lean houses given better proportion — all because of the proper use of color.

When deciding upon a color scheme for the exterior of the house, keep neighboring houses in mind. A color arrangement which of itself is harmonious may prove a disappointment because of the influence of other houses near by which are "out of tune" with it. If the house on one side is very bright and the one on the other is very dull, the middle one should be painted a color which leans to, or combines, both these colors. It should be in the nature of a transition between the two. For example, if one of the houses is a bright yellow and the other a dull gray, a soft grayed green might be used on the middle house. Such a color would contain enough gray to break the contrast between the yellow and the gray, and because of the influence of yellow in the green would afford a pleasant transition to the bright yellow.

Colonial houses are usually painted white, with green roof and window shutters. To satisfy a desire for color, however, such houses are equally beautiful when painted Colonial yellow, which is distinctly a bright, light yellow, that is neither lemon nor orange in hue. In this case, the trim is done in white and the roof and window shutters in dark green or brown. The function of color in this type of architecture is to emphasize the beautiful simplicity of the design lines.

Color combinations which are suitable for the Dutch Colonial house are: Ivory, with lettuce green for trim and shutters and red-brown for the roof; Fawn color, light cream for trim, medium brown for shutters and medium green roof. The body of a Dutch Colonial house looks well when painted a rich brown, ivory trim and shutters with deep green roof.

The Spanish or stucco type house is adaptable to unusual color treatments. Situated mostly in warm sunny climates, stucco houses lend themselves effectively to gay color treatments. For the roof tiles, reds, ranging from yellowish to brownish red, are very fitting. The rough stucco body may be delicate pink, soft light yellow, buff or terra cotta. Light greens are interesting and create an attractive freshness where the roof tiles are red. Window frames should be in a contrasting color, perhaps black or very dark brown. The wrought iron balcony rails and balusters, peculiar to this type of house, call for bright colors, and combinations of red, yellow, blue, green and black, spattered, blended or whipped together interestingly. Any lines or designs used for ornamentation are also executed in these colors.

The timber framing of houses built of cement and stucco, such as English half timbered, Italian, or Renaissance, is usually painted a dark brown or other dark tone. Roofs may be treated the same color as the timbered construction. The body is usually light buff, and window sash painted light green looks well with this combination. Light pink and very light green are also suitable for body colors.

Colors for bungalows should be selected to carry out the feeling of cosiness that this type of house suggests. In general, warm colors such as browns, buffs, creams, and ivories are the most popular, although the traditional white and green combination is in perfectly good taste. Light gray will show up beautifully, especially where there is much shrubbery. In selecting a color scheme for this type of house be sure to take into consideration the colors of the houses close by. If these are tall or in light colors, or if the house is surrounded by trees, it will be well to avoid dark colors on the bungalow as these conditions tend to give an appearance of squattiness. Painting the trim

a different color tends to make such a house appear smaller.

Brick houses need not be painted a dingy red. Any color combination that suits one's fancy and is appropriate according to the common sense rules of color selection may be used — just as in the case of wood houses. Let them be white, colonial yellow, green, buff, gray or any other color that is desired and fits the setting.

Camouflaging Ungainly Architectural Lines. — The results obtained by paint-camouflaging the exterior of a house are often quite surprising. Bad proportions may be corrected by judicious distribution of the color and selection between light and dark tones.

White, and light colors, apparently increase the size of small houses. A small house surrounded by foliage shows to excellent advantage when painted in white and such light colors as ivory, cream, buff, and golden yellow. If in a more open location, light green or light gray are good. Using one light color for body and trim will also tend to increase the apparent size.

Because dark colors tend to make a house appear smaller they are very desirable for large houses. However, when such a house is surrounded by dense foliage, warm grays and tans look better than most dark colors because they provide a better contrast. The use of a contrasting trim color defines the outlines of a building and makes it appear smaller.

A house that is too tall can be made to appear much lower if the roof is dark colored and the body a light color or white. If there are shutters on upper and lower windows, have the upper ones dark colored similar to the roof, and the lower ones the color of the body. Painting the top half of a house in a darker color than the lower half is another effective way of apparently lowering the height. If the house has dormers which are too conspicuous, particularly if the

house is tall, these should be in a color similar to the roof, thus blending them into the roof.

Using dark color on the lower part of a house and very light color on the upper part and roof will increase the apparent height. If the house is especially small and squatty-looking, dormers, if any, should be in the same color as the upper part of the body of the house, thus bringing this color up into the roof area and in this way giving the appearance of additional height.

A conspicuous outside chimney, if painted the same color as the body of the house, will not be so noticeable.

CHAPTER THIRTEEN

COLOR IN COMMERCE

There is no denying the fact that the people of today are color conscious. They usually buy or refuse to buy according to their feelings, but their feelings can be shaped to a large extent by the proper employment of color. Through such expressive mediums as interior decoration, creative art, advertising, colored illumination, the movies, etc., color has indeed definitely "come into its own."

The value of color as a sales stimulant cannot be over-estimated. When "dressed up" in a smart choice of colors both merchandise and container will most certainly attract favorable attention and create a buying urge. Some sales experts have stressed the fact that the use of appropriate color is relative in importance to good design proportions, and from the standpoint of appeal, color often has a greater influence than the service performance of the product. Be that as it may, it is an undeniable fact that its utilitarian value, and its power to arouse certain degrees of emotion and appeal, are now fully recognized.

Showmanship.—Showmanship—color applied where it is most effective, is a valuable adjunct to merchandise selling, for no matter how good an article may be, unless it is surrounded by the essential glamour of appeal, it is liable to be just another shelf warmer. One need but step inside a Woolworth store to see the sales influence of color. Toys, kitchen utensils, small tools, stationery, jewelry, pottery, glassware, enamelware, fabrics, and sundry other things displayed all around for sale are all bright with color. You see color used to attract attention in Macy's—one

of the world's largest stores, in the Sears-Roebuck stores, and in any other modern progressive business.

Oranges, lemons, raisins are all familiar fruits about which it would presumably be difficult to say anything particularly novel or appealing. Should we desire them they may be purchased at the corner store. But the great distributers of these things were not satisfied with just supplying stores, they entered into the business of sales stimulating. Their pictorial propaganda in magazines and outdoor poster displays not only tempts the appetite but illustrates new uses for their produce. Sunkist oranges and lemons, Sun-Maid raisins, Jell-o, Swift's hams, Palmolive soap, and many other nationally known products have been superbly introduced to the public by means of pictures in color. The advertisers of these products have not only demonstrated their pride in their own goods, but have produced also an advertisement for both art and color — a proof of what fine display, dignified design, appropriate lettering, and beautiful coloring can achieve as a method of salesmanship. All their advertising is based on some human buying motive rather than price appeal, and color has played a great part in its success.

Color Preference.—Certain personality traits seem to influence preference to some extent. According to psychological research many ordinary persons prefer green. Vigorous people are said to like red, while many intellectual ones favor blue. Purple seems to attract many esthetically minded people, while yellow is preferred by the egotist or self-centered person.

When a large number of persons were questioned, the range of color preferences was found to be surprisingly limited. Their favored colors fell quite readily into neat and well defined groups. This fact is constantly proved by actual experience in the sales of merchandise. In a recent analysis of the color prefer-

ences of customers based on the sales of colored wool blankets, the following figures are interesting as they clearly indicate the natural liking of people for reds and blues: — Dusty Rose, 17.3%; Blue 14.8%; Peach, 12.8%; Deep Rose, 12.5%; Green, 10.4%; Cedar, 7.5%; Dubonnet, 6.6%; Beige, 5.7%; Yellow, 4.9%; Deep Blue, 4.9%; Ivory, 2.6%.

It is the keenness of desire, not necessity, that increases the flow of merchandise consumption, and the wise advertiser studies the likings of prospective customers and capitalizes on them. Abstract color—color without any concrete purpose, on any article for sale, can render little benefit to either the seller or the buyer unless it can be interpreted in terms of the requirements of prospective customers. Business men must ever be alive to the newest trends as miscalculation may cause serious losses. Colors that sell today may lose much of their popularity and sales appeal in tomorrow's market, and wise is the merchant who keeps abreast of the subtle changes in color acceptance.

The human eye is most startled and attracted by colors that are simple, clear and pure. It responds quickly to whites that are clear and bright, and to blacks that are intense and opaque. Most people prefer tints that are clean and shades that are rich. What they do not like are in-between colors — indefinite tones which are almost impossible of classification in ordinary everyday color language.

The moral to all this seems to be that in the use of color on merchandise offered for sale, simple tones are better than subtle ones. Simple tones are more readily impressed on the memory than are odd ones. To get the most action — sales and profits, build the appeal upon the sure-fire elements of simplicity.

Color Surveys.—Since the subconscious influence of color and appearance appeal is today recognized as

one of the most potent forces in modern selling, having the right color at the right time is decidedly important.

How then can one keep posted on current trends in color preference? Color surveys — market testing, form the best methods of gauging public taste. They largely eliminate the element of speculation and reduce the risks of merely guessing.

Color surveys should be carefully planned. Approaching the wrong people at the wrong season, in the wrong location, with an insufficient range of colors would be a waste of time, effort, and money. The wise merchant does not rely on his own color taste. He realizes that there are certain colors which are most appropriate for his goods, and by conducting research he will find the right colors to assure satisfactory volume of sales and eliminate costly and unwanted inventories.

Color surveys have been successfully conducted on such matters as interior decoration, dress goods, automobiles, and many other things.

A very interesting color survey was at one time conducted by the E. I. du Pont de Nemours Company to find out what color of a car the public most favored. Prospective car buyers, covering a wide range of income groups, were contacted by mail and asked to choose, without obligation in any way, from a list of about seventy-two colors. About twenty-four per cent of them responded. The results clearly indicated that a certain maroon was the most popular.

The Wren Paper Company, Middletown, Ohio, made a survey to determine the effect of different colors of mailing pieces sent out to prospects. Ten colors of blotters were used in the survey. Approximately four thousand were sent out to ten sections of a certain city. A few days after the distribution, investigators called on the houses and succeeded in securing one

hundred interviews for each color. From the result it was found that amongst the men two-thirds favored a certain light green and one-third darker green. Among the women light blue ranked first in all cases, with light green a close second. From these results it was assumed that light green was the most effective for mixed mailings and for mailings for men, while light blue had the greatest effect in mailings intended to appeal especially to women.

The Eagle Printing Ink Company in a recent survey sets down some interesting facts on color preferences of the buying public on various commodities. Listing such products as paints, roofing, floor coverings, wall-paper, oil-cloth, mattresses, blankets, home furnishings, women's apparel, automobiles, etc., the report shows, through the sales records of manufacturers of these commodities, the great influence of color upon the buying habits of people at large.

From the experience of a department store and the headquarters of a large chain store came the following facts on color preferences in home furnishings. In best sellers, rose ranked first, then blue, beige, and green.

For kitchen items the popular colors are red, green, black and white. In the line of porcelain enamel ware white with red trim sold 34.3% of volume, ivory with green trim 34.2%, and white with black trim 31.5%.

In lithographed bread boxes, canister sets, etc., white with red trim sold 52%, white with blue trim 27%, and white with green trim 21%.

In upholstered furniture rose tones were first, beige second, burgundy third.

Mattress tickings: Blues first, rose second, grays third, and blue fourth.

From the report of a manufacturer selling a low priced towel in chain stores, mail order outlets and variety stores, Eagle quotes these facts: In colored

bordered terry towels goods are run on a basis of 35% red, 25% blue, 20% green, and the other 20% varying from run to run with peach, yellow and pink most prominent among the various shades comprising this final 20%.

Of particular interest are the reports and sales records from nine different paint companies, located throughout the country, which the Eagle Printing Ink Company recently received. One national organization offered a four-year record by color "families" for interior paints. During this period ivories accounted for 39.3% of sales, buffs 37.3%, pinks 8.2%, greens 7.3%, blues, 4.7%, and grays 3.2%. As to trend, there were slight decreases for ivories (from 39.3% down to 37.5%) and buffs (from 37.3% down to 34.6%). The demand for pinks increased (from 8.2% to 10.0%). Blues increased considerably (from 4.7% to 6.0%). The demand for green remained fairly stationary. Grays showed a slight decline.

In interior paints, white holds first place, accounting for an average volume of 48.7% among all colors. From the standpoint of consumer wants in color, however, whites are frequently bought for tinting purposes. Thus the 48.7% for white does not tell a conclusive story, inasmuch as not all consumers applied it as white paint.

A more accurate picture on the other hand, is to be drawn from an analysis of ready mixed colors. Terms such as "cream" and "ivory" are given different interpretations by different paint companies. In the following lists, "light cream" indicates off-white tints. "Ivory" signifies slightly deeper tones. The rest of the terms are self-evident.

A number of paint companies furnished the sales percentages which averaged according to the following:

Light Cream	35.5%	Gray	3.8%
Ivory	23.3%	Tan	2.4%
Deep Buff	10.0%	Pink and Rose	2.0%
Green	9.6%	Neutral Beige	1.9%
Blue	5.4%	Pale Yellow	1.7%
Peach	4.7%	Blue Green	1.2%
Deep Colors	0.5%		

In exterior paints, two companies reported the following sales percentages:

	Company A	Company B
White	34.32%	46.9%
Deep Green	10.95%	4.7%
Gray	10.65%	5.0%
Ivory	8.75%	10.9%
Cream	7.6 %	1.7%
Brown	6.96%	3.6%
Light Green	6.28%	2.7%
Black	2.42%	3.1%
Tan	2.10%	1.6%
Blue	1.67%	1.1%
Buff	1.51%	2.4%
Red	.97%	1.9%
Miscellaneous	6.36%	14.4%

Except for the wider sale of deep green and gray by Company A, the sales experience of the two companies is very much alike. In fact, white, deep green, gray, and ivory are the four best sellers in both companies, even though the order of ranking differs.

According to the sales records of one firm, waterproof cement and stucco paints sold as follows in color:

Ivory	18.65%	Green	2.44%
Gray	15.47%	Cream-White	1.92%
Cream	14.84%	Terra Cotta	1.92%
Soft White	10.90%	Grayish Tan	1.87%
Buff	6.96%	Tan	1.85%
Warm Buff	6.88%	Light Green	1.49%

Grayish White	4.30%	Pearl Gray	.82%
Blue	2.90%	Light Coral	.74%
Miscellaneous	6.05%		

In quick drying enamels, used by the consumer to decorate certain equipment in the home, the following sales percentages are reported by two companies. It will be noted that here again the figures in both columns are in good agreement.

Company A		Company B	
White	32.65%	White	36.4%
Light Cream	14.70%	Cream	14.0%
Ivory	10.12%	Ivory	6.4%
Black	6.02%	Black	6.4%
Red	5.38%	Red	3.9%
Deep Green	4.58%	Deep Blue	3.4%
Light Green	2.71%	Light Cream	3.2%
Medium Blue	2.58%	Bright Red	2.6%
Apple Green	2.53%	Light Blue	2.6%
Medium Green	2.47%	Tan	2.6%
Tan	2.26%	Deep Green	2.5%
Light Blue	2.25%	Light Green	2.4%
Maroon	1.51%	Apple Green	2.3%
Light gray	1.26%	Medium Green	2.1%
Yellow	1.20%	Brown	1.7%
Orange	1.19%	Orange	1.2%
Medium Gray	1.17%	Yellow 1.1%	1.1%
Deep Blue	1.16%	Light Gray	1.0%
Orchid	.78%	Medium Gray	.8%
Old Rose	.63%	Blue-green	.8%
Miscellaneous		Orchid	.4%
shades	2.85%	Misc.	1.2%

Green is apparently liked very well in household enamel, as in the above lists it will be noted that four greens sell 12.29% of total for Company A, and 9.3% for Company B.

As a result of this color survey, the Eagle Printing Ink Company feels that they may lessen the color

problems of the average manufacturer. An analysis of the many reports received showed that simple tones, such as ivory, green, blue, red, and the like, are the expressed preference in the vast majority of goods sold to the American public. From this we may conclude that it is best to adhere to these elemental appeals than to attempt the merchandising of off-shades and subtle tones. This, however, definitely does not apply to highly styled items such as women's fashions.

In low cost articles which reach wide markets, the color tones may be bright and geared to the impulses and emotions which are generally uniform in all persons. In more expensive lines, the manufacturer may have to study color trends in other relative products. For example, in home decoration, rugs are often purchased to harmonize with wallpaper and paint, and vice versa.

To be successful with color in commerce you must give people what you know they will accept, not what you think they want. Good sound research will help in this accomplishment.

Color in Package Design.—The growth of packaged merchandise, as seen in today's self-serve super markets, has demonstrated that successful marketing demands not only a quality product at a fair price, but real eye appeal and attention value. Whether put up in tins, boxes, or cartons, a carefully designed container, appropriately colored, has a far reaching influence on the sales of a product. Color can do much to provide character to a commodity. Some colors, inappropriately used, convey an impression of cheap and below-the-ordinary standards, while others carry with them the association with richness and high quality. Appropriateness in color therefore, needs to be carefully considered. For example, the color and design for a breakfast cereal package would be entirely out

of place if used for the container of a delicately perfumed face powder.

Containers should be so designed as to make them easily identifiable when placed among others. In this modern age of speed, when modesty and great reticence are seemingly pushed aside, it is apparent that there is not much virtue in hiding one's talent beneath a bushel. Dominance is the present-day theme, and in the sales field all lines of merchandise are undergoing design and color changes to conform to this condition.

Black on yellow is by far the most legible of all color combinations. Next in order are green on white, red on white, blue on white, white on blue — with black on white, which at first thought might be judged to be the clearest of all combinations, sixth. Where packages are to be displayed in normal light, dark characters on a light ground are best. For extremely brilliant light conditions the background may be dark and the characters light.

The employment of color in package design is mainly concerned with high attention value, ease of recognition, and memory value. Because these factors are more important than mere artistry, the primary hues have been found most successful because of their simplicity. Red with its high attention value, and blue with its universal appeal, seem to be the most predominant in successful packages. Yellow, because of its high visibility, also finds widespread use. Green has been proved to be very successful.

Other than these four hues, which, by the way, are the psychological primaries, few others are used. Offshades, and subtle tones, which may be individually and intrinsically beautiful, are often used for containers of beauty preparations and the like, and for these seem to be particularly suitable. However, such colors lack the primary qualities and hence fail to a great

extent to compel the attention or impress themselves on the memory.

Always keep in mind that no package will have legible elements unless its entire bulk first attracts attention. Carefully spaced and appropriately colored lettering is a requisite to good package design. It insures legibility. In the endeavor to make the name of the product stand out boldly, too much large and heavy lettering is sometimes crowded into too small space. In such cases it defeats its purpose, because the letters appear to run together when viewed from a short distance. All unnecessary lettering should be eliminated from the face of the package, but the name of the product and the basic message should be treated in crisp up-to-date language, easy-to-read-lettering, and appropriate coloring.

Color in Feminine Attire. — Every woman knows what an asset correct color is to her. Within herself she is conscious of the fact that she looks better in some colors than in others though she may not be aware of the reason why. She grasps eagerly at intelligent help along this line when buying wearing apparel. This desire for becoming clothes brings up the need for salespeople who have real knowledge of the effect of color on a woman's appearance and personality.

Fashion must be recognized by all commercial interests. The human source of our fashions in dress colors has for hundreds of years been Paris. In Charlemagne's time — the eighth century, Paris gained supremacy in matters pertaining to personal adornment. She has never entirely lost it, though wars and revolutions have momentarily obliterated human interest in esthetics. In recent years, however, Americans have gradually broken away from the slavish following of everything French in design and color. The creative genius of American designers is now recognized as

the equal of that of any other country. The debt we owe to Paris we will always acknowledge, but we realize that art and fashion are unquenchable and universal things.

In selling color, the important thing is that the salesperson knows something of the psychological facts regarding color — how red stimulates, green is restful, blue is cool, etc. Much along this line was discussed in Chapter One. Because of the stimulating characteristic of red, it translates its vibrant psychology to both the wearer and the beholder. When a customer feels "blue" and depressed, suggest that she try on a red dress. Her mood will probably change to one of wholesome warmth and exhilaration. A red dress is a sure tonic and may be included in nearly every woman's wardrobe.

However, there are woman who, because of their peculiar skin tone, cannot wear red effectively. Large women should be careful in the selection of reds. They should choose such reds as claret and burgundy rather than tile reds and scarlets.

Yellow, because of its sunny and lively suggestions, accents the youthfulness of the wearer. It is especially attractive for holiday and vacation wear, but should not be worn in the office, or in any other business establishment where an atmosphere of efficiency and maturity must count.

Green also is associated with youth, but is more restful in its effect than yellow. Yellowish green — the color of young leaf growths, has the freshness of youth. It always brings with it the breath of spring and the freshness of the out-of-doors. Deep rich green is especially pleasing for the business dress where its efficiently quiet tone counteracts the usual nervous tension of business places. Olive green is a hard color to wear. There is something about it that only those whose natural complexion colorings are high — the

auburn and reddish haired types, can dare to wear it.

Dark blues such as navy are conservative and sensible, but they need to be relieved by some point of brighter color or white. Light blues are extremely attractive for blondes and golden-haired types.

Dull tones of brown should never be worn without some point of interest that will tend to raise the tone. A dash of yellow, orange, vermilion or emerald will add "snap" and interest to dull browns.

To create an appearance of quiet dignity, black, relieved here and there with white, can always be relied upon. Black satin is very appropriate for such occasions. Practically every woman can wear black effectively. The exception is the slender dark woman whose skin is rather sallow, for black will give her a deathly look. Blondes with good complexion colorings, providing that they are not of the ethereal type, can always rely on black, especially when it is set off with a dash of white.

Here are some of the methods employed by the expert salespeople in the best dress stores of New York, London, and Paris. They recognize that every woman has three dominant color tones — the skin, the hair, and the eyes. The most important of these is the skin. Skin tones range from the almost white skin having a delicate pink undertone, to the dark skin which has an undertone of tan. The average skin has a tone somewhere midway between these two color types.

The skin, to a large extent, controls the colors a person should wear. A wrong choice of color in a dress may cause a skin to lose its natural loveliness.

The color of the hair is also an important factor to be considered when choosing the proper color of dress a woman should wear. Colors that are becoming to a particular type of skin, because they also go well with a certain color of hair, may greatly increase the personal beauty of the wearer.

The following suggestions will aid in choosing the proper colors for the more popular types:

Light Hair — Blonde, flaxen, golden or light brown:

Clear white skin: — Soft pastel shades are good. Avoid heavy colors. Golden and light brown hair look well in such jewel tones as jade green, sapphire blue, and others, but blondes would look "washed out" by them. Black is very becoming if the wearer is not too small. Gray is good.

Medium fair skin: — For those with this skin tone and golden hair, dresses in line with this glowing hue, such as yellow, orange, beige and brown are good. Prints, ginghams, and brocades in mixed colors that match the skin and hair are very becoming. Both black and white are good, but grays should be avoided. Blues and greens must be chosen with care as the wrong shades will dull the complexion.

Golden or dark skin: — Light pastel shades of the clear jewel tones are good. Navy blue or black, when accentuated with trimmings of bright color, are very becoming. Other dark colors should be avoided. White is good.

Reddish Hair—titian, auburn, and chestnut: —

Clear white skin: — All soft cool colorings in tones less intense than the hair are very good. Intense, warm colors dim the glory of this glamorous hair coloring. Most dark colors are too heavy. Black should not be worn unless accentuated with some bright color.

Medium skin: — Colors that correspond in brightness with the hair, such as light tones for titian and darker shades for auburn, are very appropriate. Intense colors should be avoided. This type is subject to freckles, so avoid browns, tans, and certain shades of orange and yellow, which accentuate the freckles.

Dark skin: — Rich, deep, colors heighten the beauty of this type. Warm reddish browns, bronze greens,

and rich yellows are good. White, pale pink, beige, and pale orchid are also very suitable. Vivid blues and greens make this skin sallow looking.

Dark Hair—Brown and black: —

Clear white skin:—Practically all colors may be worn effectively by this type. Black should be relieved with some brighter color.

Medium skin:—Pastel shades are all good. Rich warm colors such as wine reds and glowing browns accentuate this type of beauty. Blue, green, and gray, in medium tones, are appropriate. Navy blue is to be preferred to black.

Dark skin:—Rich dark reds, dull orange, browns, and beige are best for this type. Creamy white, palest pink, and pale peach are all excellent. Blues and greens unless carefully selected tend to make the skin sallow looking. Purple and orchid are hard for this type to wear.

Correctly chosen color will accentuate the especial charms, bring out the delicacy of the complexion, intensify the beauty of the hair and eyes, and give that essential glamour which is the desire of all women.

Color for Style Appeal.—One of the strongest factors in the sale of any article, product, or service, is "style appeal." This has been proved time and time again, especially in the feminine realm. When a woman believes that she is getting something a bit out of the ordinary, she becomes interested — her innate vanity asserts itself. She just can't help it!

Clothing manufacturers have capitalized on the feminine desire for exclusiveness and glamor. They have created new, and often-times romantic sounding names for ordinary colors. When the season's new styles in ladies' apparel are placed on display, most women are attracted to the beautiful colorings, and the desire for possession of some article in these attractively-named new colors is aroused.

Knowing the power of style appeal to awaken favorable responses, the successful merchant uses it when endeavoring to sell anything in which color finds a predominant place. The decoration of homes furnishes another instance of which style appeal might be used advantageously. To illustrate: Mr. Brown and Mr. Gray, both expert interior decorators, are offering color suggestions to a woman prospect for the decoration of one of the rooms in her home. Mr. Brown suggests "light orange" as an appropriate color and Mr. Gray's suggestion is "peach bloom." Peach bloom is light orange, both are alike, yet Mr. Gray with his "peach bloom" will be almost sure to get the contract to do the work, while the "light orange" of Mr. Brown will probably only receive passing consideration.

Such terms as Sea Foam, Harlequin, Lucille, Reseda, and Pistachio, certainly have much greater appeal than light green, medium green, etc. The same goes for Arbutus, Rose Breath, Camelia, Cevera, and Cameo, for pinks and reds. When discussing tones of orange, names such as Peach Bloom, Apricot, Coral, Congo Pink, and Emberglow, are sure to command attention, as are Goldenrod, Honeydew, Maize, and Gold, when speaking of yellows.

The wise salesperson will familiarize himself with the color tones such names represent. Judiciously using them, along with the standard color names, will be immensely helpful in creating in the mind of the prospective customer the kind of impression that brings into being the urge to buy.

Color for Eye-Appeal.—Color may be all-important in the sale of many commodities and its effectiveness from the standpoint of eye-appeal has been proved many times both by test and experience. When a prominent department store in one of our large cities changed its newspaper advertisements from black and white to color, using the same publication space, the

average sales increased from 35 thousand dollars attributed to the black and white advertisements, to 130 thousand dollars after introducing color.

An electrical concern manufacturing flat irons equipped them with black handles and through this lost a 250-thousand dollar South American order to a shrewd competitor who, knowing something of the color preferences of his prospective customer, used red handles.

Nutritionists say there is no difference in eggs whether their shells are white or brown, providing their other qualities are equal. Nevertheless, the fact remains that in some markets one or the other color will sell exclusively because buyers think they are better or because they prefer the particular color. White eggs have been found to sell best from blue-lined cartons, but brown eggs sell better from containers lined with white.

A Hudson Valley grower of Northern Spy apples was penalized on price in the New York market because his apples were deemed off-color — they were "too red" in comparison with what the trade and the public thought a Northern Spy apple should be.

During the second World War, because of the lack of experienced help, a southern Illinois tomato canning concern had a problem on their hands. The inexperienced tomato gatherers did not know the exact color tomatoes should be for canning purposes. Some were gathered too ripe, others too green. The problem was solved, however, by Professor Harry Short of Purdue University. He developed a paint having the same tone of red that tomatoes should have when picked. He then had all the pickers paint their fingernails with this paint. On reaching for a tomato, the picker would match the nail paint with the skin of the tomato, and if they harmonized the tomato was picked.

For some psychological reason, certain colors in relation to food appear appetizing, while other seem distasteful. Because of our past associations and experiences we become familiar with the most desirable color for quality in meat, for ripeness in fruit, for freshness in vegetables, etc. In presenting food for sale these definite ideas about color must be recognized and kept in mind.

A wrong color scheme in the establishment where food is offered for sale may cause emotional conditions in the prospective customer which might tend to repel rather than attract. It may also so affect the appearance of the food on display as to give an impression of staleness. A meat market located in the famous stockyards of Chicago one time found its business dwindling at an alarming rate. It was an old established concern which prided itself on the high quality of its meat products and the general inviting appearance of its display room. The display room had been painted in a bright sunshiny yellow and the management anticipated an increase in business as a result. They were shocked, however, to find sales falling off at an alarming rate instead. In their distraction they consulted color experts. They were informed that the bright yellow, which of itself was an uplifting and cheerful color, in this case had actually had an opposite effect. Because yellow always produces a blue after-image, the rich, red meat took on a purplish hue which made it appear stale and even spoiled. A bluish-green tint was suggested because the red after-image from this would enhance the red. The meats became more inviting than ever and the anticipated increase in business became a fact.

CHAPTER FOURTEEN

COLOR TO PROMOTE INDUSTRIAL EFFICIENCY

American industry has spent millions of dollars on time-and-motion studies to promote employee efficiency, increase production, and at the same time minimizing body fatigue. Many times the changes recommended as a result of these studies are seemingly insignificant. For example, the chair the worker sits on is raised or lowered an inch or two, the handle of a tool is shortened slightly, or the position of the tray or rack that contains the material in process is changed, and as a result the productivity of the operator who uses that chair, tool, tray or rack is increased. Only trifling changes these, but considered over a period of time they are tremendously important.

Time-and-motion study, however, has not been entirely successful in minimizing fatigue. There are other factors that must be taken into consideration.

Illumination and Hight Light Reflection.—Until recently, except in the field of illumination, very little study has been attempted to provide "better seeing" conditions as a means of eliminating fatigue. Factory interiors have been painted a dazzling white, the main reasons for so doing being for cleanliness, sanitation, and high light reflectance. Attention has also been given to providing adequate illumination for good seeing, but in many instances, the illumination has been too intense. High light reflectance and too intense illumination usually produce too much glare, and as a result, the eyes become tired and strained.

Eye Fatigue.—Many of the conditions which cause visual fatigue are now being effectively dealt with

through the intelligent use of color. It may be hard to believe that color on a wall or on a machine can have a marked influence on worker morale, production output, workmanship standards, safety, fatigue, etc. But color does have an important bearing on these conditions and is being extensively and soundly used by many industrial concerns as an aid to better seeing.

Eye movements depend upon muscular action. Seven muscles motivate the eyeball. When the iris expands or contracts, for the purpose of making the pupil larger or smaller, the effort of the sphincter muscle is required to constrict the pupil, and on relaxation of the sphincter muscle the elastic connecting tissue fibers of the stroma pull the pupil open. Actuation by the ciliary muscle shapes the lens and causes it to properly focus objects in the visual field upon the retina.

Just like any other muscles, eye muscles get tired, but, strange as it seems, this tiredness is usually not first felt in the eye itself, but many communicate itself to other parts of the body, causing a general tired feeling, headache, nervous and muscular tension, lowered visual acuity, and other disturbances.

Eye fatigue, and its accompanying disturbances, tend to slow down the worker and cause quality and quantity production to suffer.

Causes of Eye Fatigue.—Poor visibility, inadequate illumination, glare, extreme adaptive changes from light to dark and vice versa, prolonged fixation of the eyes, and lack of suitable areas for visual relaxation, are many of the causes of eye fatigue.

When the color of the material a worker is fabricating is too much like the immediate color of the machine eye strain may result because of the extra effort required to differentiate between the two. Staring steadily at some task being performed soon tires the eyes.

Because eyes are more comfortable when the direction of the gaze is frequently changed, it may be found both natural and restful to glance up from the work being done from time to time, providing that the eyes in so doing are not required to adjust themselves too much in the change. Illumination and color properly planned in surrounding areas will be a big factor in the effort to hold down to a minimum eye fatigue. If the working area is well illuminated and the surroundings are dark, the effect of changing the gaze will be to require eyes to adjust themselves for a different light intensity and readjustment when the gaze is returned to the work.

Color for Better Seeing.—Due to the ever increasing demands upon the eyes because the tempo of modern production is so much faster and requires much greater accuracy, precision, and visual acuity, management in collaboration with expert colorists and psychologists have given much thought and consideration to the use of color along with illumination in an effort to provide "better seeing" conditions. When used in the workroom, color need not be garish, and need not subtract anything from the standpoint of light reflectance. Cheerfulness, restfulness and good visibility should be the fundamental aim.

In the past it has been customary to paint factory walls in dazzling white, the main objective in so doing being to provide higher light reflection. Intense illumination and high light reflectance are all right in their place, but in the workroom these conditions may produce so much light that the individual worker is almost "flood lighted." There is too much light and glare with accompanying dark shadows, all of which cause eye strain. In place of white, there are many tints having nearly as good light reflection factors as white but which have the added characteristic of providing pleasanter conditions. Some light colors are

uplifting, some are restful — easy on the eyes. Why not use them? Eyes that are not strained or tired see better, react quicker.

A Case History.—Take the following case history as it appeared in "Building Maintenance" Volume 3, Number 2, published by the Truscon Laboratories, Inc., Detroit, Mich. In the inspection department for military lenses, in one of the Libby-Owens-Ford Glass plants, employees were having an exceptional amount of eye trouble. So much trouble, in fact, that their well trained and equipped medical department was fighting a losing battle with eye strain casualties.

In this department the girls sit before inspection machines which project a narrow slit of strong light through a glass lens. The work is very tiring on the eyes, so much so, that after each inspection, the operator is instructed to look up from her work to rest her eyes. But her eyes were not rested.

At first, it was thought that the walls and ceiling of the room were too bright, and excessively dazzling. This surmise was correct, as it was noted that it took several seconds for the eyes to adjust themselves to the light change when looking up from the work to the wall, or back to the work again. This not only slowed the inspection — it was a decided strain on the eyes.

Darker colors were then tried on the walls. This was some improvement, but the eye casualties still continued. Black was tried on one wall, but this was worse. Evidently it wasn't brightness alone that caused the eye trouble.

At this point, Mr. H. Creston Doner, in charge of Libby-Owens-Ford's Department of Design, started some experiments with "tempered whites" — that is, whites which had the "curse" of eye confusing brightness taken away with minute quantities of color.

One such white was a whispy tint of warm blue. You

couldn't call it a "blue tint" because blue tints generally have a washed out appearance. Besides, this tint did not appear to be blue at all.

Walls and ceilings painted with this color seemed immediately to make a marked difference in eye comfort and visibility. The difference was so noticeable that the workers with one accord exclaimed, "My, that is really restful."

After this new color was applied to both walls and ceiling in this department, fully 90% of the "eye trouble" disappeared. Operators no longer complained of smarting or itching eyes; they felt better satisfied, happier on their jobs, and, as a result, output increased immediately.

Morale.—Morale is a word that is used quite frequently when referring to the state of mind of factory employees. Morale is a very sensitive thing. It fluctuates. It has the characteristic of being "up" or "down"; "high" or "low." If employees are enthusiastic about their work, their morale is said to be good or high. The morale of dissatisfied workers is usually low.

There are many factors that contribute to employee morale. Working conditions, surroundings, illumination — all have some effect on the mind and body of the worker. In the effort to produce the best working conditions, walls and ceilings of workrooms have usually been painted white, and the illumination made as bright as possible, but often these have failed to create an entirely satisfactory condition. Workers in such rooms have been heard to exclaim when coming outdoors, "What a grand and glorious feeling." Without a doubt this feeling of relief is not entirely due to the change of air, but to a great extent to the relief from tension caused by the brightness of the workroom and to the introduction of color to eyes that have been robbed of their natural desire for color.

Because of the physiological and psychological effect of color on a worker's eyes, and body, it has an important function to perform, along with illumination, in promoting the well-being of the individual and maintaining high morale.

Color Applied Scientifically.—Color and illumination in factory interiors should not be considered just merely as part of the building plan or part of the general scheme of making the place look clean and orderly, they are also part of the health, comfort and well-being of the occupants. For this reason, the proper use of color in the workroom is of utmost importance and needs careful consideration.

The type of color treatment is determined through a study of the plant, its location, the location of the various departments, the kind of work being performed, and the equipment. In factories where temperatures are relatively high, cool light tones of blue and green are appropriate. Soft warm buffs and suntone creams are desirable to add apparent warmth to cool locations.

In inspection and assembly departments handling intricate devices, neutral light soft grays will establish proper eye adjustments without competing for attention. Very light gray, approaching white, may be used on walls and ceilings. A darker tone of this same gray is recommended for dado or wainscoating. It should not be dark like customary dado colors, but just dark enough not to show finger marks plainly, and not to contrast too much against the wall areas. For high parts of machinery above eye level, a slightly darker tone of the wall color blends nicely into the wall background. Window and door frames, switch and fuse boxes, and similar items on the wall areas should be treated with this same color. This color

For machinery bases, benches and other equipment below eye level, a dark neutral gray is suitable.

Pipe lines running along walls and ceilings should be painted the same color as the adjacent wall and ceiling areas. This also applies to steel bracings and masonry and steel columns.

The reason for painting ceilings, together with overhead steel work, beams, cross bracing wires and pipes in light tones is because these are receding colors. Thus treated, they become inconspicuous and do not "bear down" on the worker.

Should a machine be in such a position that the wall of the room is constantly in the worker's field of vision, it is advisable to use colors that rest the eyes rather than stimulate them. If the wall is dark and the machine light, or if the wall is light and the machine is dark, the eye has to make quick adjustments when directing the vision from the machine to the wall and back again. The energy required to make these adjustments for only a few times is very slight, but when multiplied by several hundred during the course of a day, eye strain and fatigue are very likely to result. To overcome this unsatisfactory condition, eye-rest surfaces — those frequently glanced at for a change, should have approximately the same brightness as the working surface.

Regarding this subject of eye-rest surfaces, a cheerful yet restful atmosphere is created if one or more walls, against which no machines are located, be painted with a sunny yellow. This satisfies the natural demand of the eye for color to relieve tension.

Focal Colors.—Eyes are naturally attracted to the brightest area in the field of vision and automatically turn to, and rest upon it. This factor is utilized as an important part of the employment of color for better seeing. The critical or operating parts of machines have been painted with color that attracts the eye.

This color stands out in strong contrast to the stationary or non-critical parts of the machine. Because this color focuses the operator's attention where it should be, it is called "focal color." It commands eye attention and reduces unnecessary involuntary eye movement which occurs when the whole machine is the same color.

The selection of the proper focal color is important. It should be in sharp contrast to the non-critical parts of the machine and should also afford a clear-cut contrast with the material being fabricated. As an example, light gray used as a focal color where the material being fabricated is aluminum or stainless steel is completely wrong. Because there is no easy-to-see line of division, the operator is constantly straining his eyes to see where the material ends and the machine begins. Tan, buff or orange would afford a good contrast in this instance. If brass is being fabricated, blue-green would be a good focal color because it forms an ideal color to offset the orange hue of brass. Intelligently applied, focal color discourages "eye travel," affords improved visibility, and relieves nervous tension.

Color for Safety.—There seems to be no general or universal standard in industry in the use of color for safety, etc., apart from red as a means of identifying fire equipment. Recently, there have been attempts to promulgate the use of standard colors to indicate accident hazards, identify protective equipment, and assure orderliness and good housekeeping. As a result of experiments and research by expert colorists, paint makers, and industrial concerns, six colors have been suggested as most suitable. They are yellow, orange, green, red, white and blue.

Each of these colors may be used to indicate a distinct type of hazard, or to establish some specific type of identification.

Yellow, because of its high visibility under most conditions, is an appropriate color where it is desired to attract the attention. When used with black in alternate stripings it may indicate the presence of such hazards as trucking equipment, edges of platforms and pits, aisle obstructions, pillars in line of traffic, protruding parts, curbings, dead-ends, low beams, etc.

Orange is a color of immense "drawing power." It combines the high visibility of yellow with the intensity and vitality of red. It is for use on dangerous parts of machines and equipment such as cutting devices, machinery guards, exposed parts of pulley, gears, etc., chain host blocks, interior surfaces of electrical switch boxes and power boxes.

Green is the color traditionally associated with safety practice. It is used to mark all first aid equipment such as containers for goggles, cabinets for gas masks, respirators, medical supplies, stretchers and first aid stations.

Red, because of its association with fire, has long been used to locate and indicate apparatus for combating fire such as extinguishers, hose connections, hydrants, alarm stations, fire exits and such like.

White, because it is conducive to cleanliness, serves for use on storage tanks, waste receptacles, floor areas immediately surrounding waste receptacles, corners, etc.

Blue is used to indicate the need for caution. It finds application on equipment and apparatus not to be used, moved or started, such as electrical controls, valves, dryers, ovens, scaffolding, etc.

All aisles and traffic lanes should be painted a different color from the rest of the floor area, or else wide stripes of a bright color such as yellow should be laid down to serve as boundary lines. Doing this attracts the worker's attention, warning him that he is "in the street" and must be on the alert.

Scientifically employed, color does much to increase production, thereby offering more profits to management, greater remuneration for the worker, and a general feeling of enthusiasm and satisfaction all around.

It is interesting to note the reaction of the workers in a number of departments at the Taylor Instrument Companies, Rochester, New York, where color was carefully and scientifically introduced during World War II, by Mr. P. R. Jameson, Vice President and General Superintendent.

Here is what they say:

"Better impression when entering."

"Employees are quieter and more attentive to their work."

"It encourages us to keep a clean and neat working department."

"Reduction of glare makes clerical work less fatiguing."

"It gives better light and does away with all glare."

"Operators do not complain of headaches and eyestrain anymore. This means less absenteeism."

"Approximately ten per cent increase in the department 'B' average since its application."

"A contributing factor to the fine production record this department has made."

CHAPTER FIFTEEN

COLOR NAMES AND MIXING FORMULAE

Color is one of the foremost means of indicating style in dress fabrics, decoration and design. As such, therefore, it will ever be subject to change. New and different colors will "come out" with each season, and will be promoted as the very latest styles. The public, especially the ladies, who use color judiciously in dress, who select most of the colors for decorating homes and who buy most of the things considered necessary to our everyday existence and comfort, will accept the stylish colors by their new names and will specify them when the need for color selection arises.

So-called stylish color names come and go, yet, certain of them seem to "click" and they remain with us and become more or less standard. Among these are Alice blue, amber, apricot, beige, coral, mulberry, peach, taupe and a host of others.

There are other color names, generally accepted by those who use color for interior decoration, which are described by compound words, which indicate definite color ideas. This means of color designation is both natural and practical. For example, we have a definite idea in mind of an orange color. It is midway between a lively red and a bright yellow, and is neither too red nor too yellow. But supposing that we want to designate an orange tone that leans a little toward red; it would be called red-orange. To designate an orange tone that leans toward yellow, it would be called yellow-orange. A color such as rose-gray is produced by mixing black and white to make gray, plus a small amount of red to give it a slightly reddish hue.

In another group we have what are called "base colors." These are standard colored pigments or colorants. Among them are raw sienna, burnt sienna, raw umber, burnt umber, venetian red, vermilion, crimson, magenta, vandyke brown, ultramarine blue, cobalt blue, prussian blue, all the chrome yellows and the chrome greens. They are subject to very little variation in hue. Other colors may come and go but these are always with us.

Users of color need to know the latest color styles, their names and how to mix them. In Chapter Five we discussed the mixing and matching of colorants. It is now our intention to follow this up with a presentation of formulae for mixing many of the colors that are considered stylish for fabrics, decoration and design.

It must be kept in mind that these formulae are to be mixed on the weight basis and not on the volume or bulk measure. They are approximate only. Experience has shown that some pigments have greater tinctorial strength than others and so less weight of them is required than with others. Then again, different weights of tinting colors may be needed to bring the various brands of zinc white, titanium dioxide, lithopone, white lead and other basic pigments used in gloss paints, flat paints or enamels to a given color. However, the following formulae give a good idea as to the amount of tinting colors required, and assuming that the mixer knows what a specified color looks like, he should experience no difficulty in obtaining it.

COLOR NAMES AND MIXING FORMULAE

Alabaster

White	60
Medium chrome yellow	1

Alabaster yellow

White	4
Medium chrome yellow	1

Alice Blue

White ---------- 10
Cobalt blue ---------- 1

Almond

White ---------- 3
Raw Sienna ---------- 1

Almond green

White ---------- 75
Medium chrome green 9
Venetian red ---------- 2

Amber

Burnt umber ---------- 5
Medium chrome yellow ---------- 9
Orange chrome yellow 8

American Beauty Rose

American vermilion ---------- 12
Rose Lake ---------- 2

Amethyst

White ---------- 16
Rose Lake ---------- 1
Prussian blue ---------- ¼

Anemone

White ----------100
Tuscan red ---------- 3
Cobalt blue ---------- 1

Antrim green

White ----------100
Medium chrome green 3
Medium chrome yellow ---------- 4

Apple Green

White ----------100
Medium chrome green 3
Medium chrome yellow ---------- 4

Apricot

White ---------- 28
Orange chrome yellow 1

Armenian Red

English vermilion ---------- 75
Medium chrome yellow ---------- 1

Argent

White ---------- 16
Lampblack ---------- 9
American vermilion ---------- 1
Orange chrome yellow ¼

Ash Gray

White ----------100
Vandyke brown ---------- 1

Ashes of Roses

White ---------- 50
Rose Lake ---------- 2
Raw sienna ---------- 1

Athenia

White ---------- 32
Indian red ---------- 1
Burnt sienna ---(touch of)

Autumn Brown

White ---------- 21
Burnt umber ---------- 1
Burnt sienna ---------- ½

Azure Blue

White ---------- 75
Cobalt blue ---------- 4
Prussian blue ---------- 1

Baby Blue

White ----------120
Prussian blue ---------- 1

Baby Pink

White ----------120
English vermilion ---------- 1

Battleship Gray

White	120
Raw umber	2
Lampblack	1

Bay

Drop black	10
Venetian red	10
Orange chrome yellow	1

Beach Gray

White	40
Raw umber	1

Beaver Brown

White	70
Burnt umber	20
Medium chrome yellow	1

Bedford Stone

White	100
Raw sienna	3
Lampblack	(touch of)

Beige

White	75
Burnt umber	2
Vandyke brown	1

Begonia

White	44
Mauve	3

Bermuda Pink

White	54
American vermilion	5
Orange chrome yellow	2

Bisque

White	75
Raw sienna	4
Raw umber	1

Bittersweet

Orange chrome yellow	6
American vermilion	5

Bluet

White	48
Cobalt blue	12
Mauve	1

Blush Pink

White	85
Raw sienna	2
Burnt sienna	1
Tuscan red	(touch of)

Bois de Rose

White	100
Raw sienna	1
Indian red	1

Brass

White	40
Light chrome yellow	12
Raw umber	1
Burnt umber	1

Brittany Blue

White	55
Prussian blue	1
Burnt sienna	(touch of)

Briar Rose

White	65
Tuscan red	1
American vermilion	(touch of)

Buckskin

White	45
Light chrome yellow	1
Raw sienna	1

Buff

White	75
Raw sienna	6
Medium chrome yellow	1

Burgundy

Rose Lake	5
White	1
Ultramarine blue	1

Burnt Orange

Orange chrome yellow	20
Burnt sienna	1
English vermilion	1

Burnt Rose

White	24
Raw sienna	1
Rose Lake	1

Buttercup

White	10
Medium chrome yellow	1
Light chrome yellow	1

Cadet Blue

White	40
Prussian blue	3
Venetian red	1

Cafe Creme

White	70
Raw sienna	2
Vandyke brown	1

Cafe Au Lait

White	42
Vandyke brown	1
Raw sienna	2

Camel

White	50
Raw umber	2
Raw sienna	1

Camelia

White	17
American vermilion	1

Cameo Pink

White	48
American vermilion	1
Medium chrome yellow	(touch of)

Canary Yellow

White	70
Light chrome yellow	8
Medium chrome yellow	2

Chartreuse Green

White	33
Medium chrome green	2
Medium chrome yellow	1

Cherry Red

Chestnut	28
Burnt umber	8
Tuscan red	1

Chin-chin Blue

White	40
Prussian blue	2
Tuscan red	1

China Pink

White	130
Tuscan red	4
Indian red	1
American vermilion	1

China Rose

White	25
Tuscan red	4
Indian red	1
American vermilion	1

Champagne

White	160
Raw sienna	8
Light chrome yellow	2

Chocolate Brown

White	100
Burnt umber	22
Burnt sienna	12
Raw sienna	12

Ciel Blue

White	300
Prussian blue	1

Cinnamon Brown

White	35
Burnt umber	6
Medium chrome yellow	3

Citron Yellow

White	52
Light chrome yellow	48
Medium chrome green	1

Claret

Mauve	1
American vermilion	1

Clematis

White	100
Cobalt blue	3
Mauve	1

Cleopatra Blue

White	50
Prussian blue	1
Cobalt blue	8

Carnation Red

White	4
English, or scarlet vermilion	7

Carnation Rose

White	7
English, or scarlet vermilion	1

Carrot

American vermilion	1
Orange chrome yellow	4

Cedar

White	115
Medium chrome yellow	3
Burnt sienna	3
Burnt umber	2

Cedar Brown

White	2
Burnt sienna	2
Burnt umber	1
Medium chrome yellow	1

Celestial Blue

White	33
Prussian blue	1

Ceramic Blue

White	18
Prussian blue	1
Light chrome yellow	(touch of)

Cerise

White	6
Vermilion (scarlet)	1

Cevera

White	3
Scarlet vermilion	1
Mauve	1

Coffee

White	10
Burnt umber	3

Coral

White	40
English vermilion	6
Medium chrome yellow	1

Cocoa

White	115
Burnt umber	25
Indian red	2

Cochin Red

English vermilion	12
Medium chrome yellow	1

Colonial Yellow

White	100
Medium chrome yellow	2
Raw sienna	1

Copenhagen Blue

White	30
Prussian blue	2
Tuscan red	1

Copper Brown

White	8
Raw sienna	3
Burnt sienna	1

Corn

White	100
Medium chrome yellow	3
Raw sienna	1

Cornflower Blue

White	120
Prussian blue	1
Tuscan red	1

Crab Apple

White	100
Scarlet, or English, vermilion	1

Cranberry

Scarlet vermilion	5
Mauve	1

Cream

White	100
Raw sienna	1½
Medium chrome yellow	(touch of)

Creme Mode

White	70
Raw sienna	2
Vandyke brown	1

Creole Brown

White	35
Venetian red	2
Vandyke brown	2
Raw sienna	1

Cyclomen

White	25
Mauve	1
Scarlet, or English, vermilion	1

Daffodil Yellow

White	100
Medium chrome yellow	9
Scarlet vermilion	1/4
Cobalt blue	1/4

Delft Blue

White	72
Prussian blue	4
Burnt sienna	1/2

Delphinium Blue

White	5
Cobalt blue	1

Dove Gray

White	150
Vandyke brown	1
Raw sienna	1
Burnt umber	1

Drab

White	130
Medium chrome yellow	4
Lampblack	1

Dresden Blue

White	200
Prussian blue	1

Dull Gilt

White	30
Light chrome yellow	3
Raw sienna	1

Dusk blue

White	65
Ultramarine blue	5
Raw umber	1

Dust

White	80
Ivory, or drop, black	3
Medium chrome yellow	1

Dutch Blue

White	12
Ultramarine blue	5

Ecru

White	105
Light chrome yellow	1
Raw sienna	1
Raw umber	1

Eggplant

Ultramarine blue	4
Mauve	3
Drop black	1

Egyptian Red

White	3
Scarlet vermilion	2
Venetian red	1

Electric Blue

White	5
Cobalt blue	2

Elephant

White	15
Raw umber	2
Lampblack	(touch of)

Empire Blue

White	18
Prussian blue	1
Light chrome yellow	(touch of)

Evenglow

White	120
Cobalt blue	5
Tuscan red	1 1/2

Eucalyptus

White	4
Raw sienna	2
Medium chrome green	1

Evergreen

Dark chrome green	12
Lampblack	1

Fawn

White	20
Burnt umber	2
Vandyke brown	1

Fire Red

English, or scarlet, vermilion	10
Medium chrome yellow	¼

Flesh

White	85
Raw sienna	2
Burnt sienna	1

Fog Blue

White	160
Ultramarine blue	3
Chrome green	1

Fog Gray

White	175
Lampblack	1

Forest Brown

White	20
Raw sienna	3
Burnt umber	2

Forest Green

Medium chrome green only

Forget-Me-Not

White	90
Prussian blue	1

French Beige

White	14
Burnt umber	1

French Blue

White	40
Prussian blue	3
Venetian red	1

French Gray

White	35
Lampblack	1
Raw sienna	(touch of)

French Yellow

Medium chrome yellow	12
Orange chrome yellow	3
Burnt umber	1

Fuchsia

White	25
Mauve	5
Scarlet vermilion	1

Gazelle

White	180
Venetian red	1
Indian red	1
Lampblack	1

Geisha Pink

White	140
American vermilion	6
Mauve	1

Gentian

White	95
Cobalt blue	10
Mauve	1

Geranium

Scarlet, or English, vermilion	2
Alizarin crimson	1
White	1

Gobelin Blue

White	50
Cobalt blue	8
Prussian blue	1

Gold

Light chrome yellow	20
White	9
Venetian red	1

Golden Brown

Burnt umber	12
Medium chrome yellow	8
Venetian	2

Goldenrod

White	5
Light chrome yellow	3
Medium chrome yellow	1

Golden Tan

White	42
Raw sienna	3
Burnt sienna	1

Golden Wheat

White	65
Raw sienna	3
Burnt sienna	1

Golden Yellow

Light chrome yellow	21
White	9
Venetian red	1

Gooseberry Green

White	40
Emerald green	18
Medium chrome green	2
Light chrome green	1

Goya Red

American vermilion	2
Alizarin crimson	1
White	1

Grapenut

White	140
Raw sienna	14
Light chrome yellow	3
Burnt sienna	2
Raw umber	1

Grecian Rose

White	35
Venetian red	1

Gypsy Red

Scarlet, or English, vermilion	2
Alizarin crimson	1
White	1

Havana Brown

Raw sienna	3
Burnt umber	2

Haviland Blue

White	36
Prussian blue	1
Raw sienna	1

Heather

White	50
Cobalt blue	2
Alizarin crimson	1

Helen Pink

White	115
Scarlet vermilion	8
Medium chrome yellow	1

Heliotrope

White	20
Ultramarine blue	2
Alizarin crimson	1

Henna

White	5
Burnt sienna	2
Indian red	1

Hepatica

White	55
Mauve	2
Alizarin crimson	1

Holly Green

Medium chrome green	5
Lampblack	1

Holly Red

Alizarin crimson	4
Scarlet vermilion	4

Honey

White	100
Raw sienna	3

Honeydew

White	80
Orange chrome yellow	1
Medium chrome yellow	1

Hydrangea

White	150
Prussian blue	1

Imperial Blue

White	2
Ultramarine blue	2

Independence Blue

White	2
Prussian blue	1

India Buff

White	88
Raw sienna	12
Lampblack	1

Indian Orange

Deep chrome yellow	20
Scarlet vermilion	1
Burnt sienna	1

Invisible Green

Deep chrome green	8
Lampblack	3

Iris Violet

White	130
Mauve	3
Ultramarine blue	1

Italian Blue

White	200
Prussian blue	3
Light chrome yellow	1

Ivory

White	100
Raw sienna, or, Yellow ocher	1

Ivy

Raw sienna	40
Prussian blue	2
Lampblack	1

Jade

White	200
Light chrome yellow	3
Prussian blue	1

Japanese Red

English vermilion	3
Alizarin crimson	1

Jonquil Yellow

White	100
Light chrome yellow	1
Lemon chrome yellow	1

Kashan Blue

White	90
Prussian blue	2
Light chrome green	1

Kashmir Gray

White	45
Vandyke brown	2
Medium chrome green	1
Lampblack	1

Khaki

White	120
Raw sienna	70
Raw umber	4
Lampblack	1

Kobe Red

Venetian red	3
American vermilion	1

Laurel

Medium Chrome green	1
Lampblack	(touch of)

Lavender

White	30
Ultramarine blue	2
Alizarin crimson	1

Lead Color

White	100
Lampblack	2

Leaf Brown

Medium chrome yellow	8
Burnt umber	12
Venetian red	2
White	2

Leaf Green

Light chrome green	10
Light chrome yellow	10
White	1

Lemon Yellow

White	15
Lemon chrome yellow	1

Lettuce Green

White	25
Light chrome green	2
Light chrome yellow	1

Lilac

White	50
Ultramarine blue	1
Alizarin crimson	1

Limestone

White	100
Yellow ocher	2
Raw umber	1

Llama Gray

White	100
Yellow ocher	6
Venetian	¼
Lampblack	(touch of)

Lucerne Blue

White	6
Cobalt blue	1

Lucille

Medium chrome green, straight.

Maize

White	40
Medium chrome yellow	1

Maroon

Tuscan red	2
Alizarin crimson	1
Ultramarine blue	1

Mauve Blush

White	160
Rose Lake	5
Deep chrome yellow	1

Mauve Rose

White	36
Rose Lake	5
Deep chrome yellow	1

Mayflower Pink

White	235
Indian red	1

Melon

White	42
American vermilion	10
Rose Lake	2

Midas Green

White	12
Medium chrome green	1

Midnight Blue

Drop black	15
Cobalt blue	14

Milwaukee Brick

White	85
Raw sienna	6
Burnt umber	1

Mist Blue

White	120
Cobalt blue	3
Vandyke brown	1

Misty Morn

White	165
Tuscan red	1
Cobalt blue	1
Vandyke brown	1

Mode

White	120
Raw umber	2
Burnt umber	1

Mole

White	65
Burnt umber	8
Prussian blue	1

Monet Blue

White	100
Cobalt blue	68
Lemon chrome yellow	1

Moorish Red

English vermilion	3
Alizarin crimson	1

Moss Green

White	3
Raw sienna	2
Medium chrome green	1

Mouse

White	65
Burnt umber	10
Prussian blue	1

Mountain Blue

White	8
Cobalt blue	6
Ivory black	2
American vermilion	1

Muffin

White	75
Raw sienna	25
Venetian red	1½

Mulberry

White	40
Tuscan red	6
Cobalt blue	1

Nile Green

White	100
Light chrome green	2
Medium chrome yellow	(touch of)

Nasturtium

Scarlet vermilion	3
Medium chrome yellow	1

Olive Brown

Burnt umber	3
Light chrome yellow	1

Olive Drab

White	50
Raw umber	8
Medium chrome green	5
Lampblack	1

Olive Green(dark)

Ivory black	10
Yellow ocher	4
Medium chrome yellow	2

Olive Green, (light)

White	50
Medium chrome yellow	3
Raw umber	3
Ivory black	1

Old Blue

White	20
Prussian blue	1
Lampblack	(touch of)

Old Gold

Yellow ocher	12
White	6
Medium chrome yellow	3

Old Rose

White	60
Tuscan red	1
American vermilion	(touch of)

Orange Pink

Orange chrome yellow	1
White	4

Orange Brown

Orange chrome yellow	1
Burnt sienna	1

Orchid No. 1

White	100
Cobalt violet	15

Orchid No. 2

White	100
Ultramarine blue	4
Alizarin crimson	5

Oriental Blue

White	25
Prussian blue	2
Light chrome yellow	1

Oriental Green

White	2
Light chrome yellow	2
Raw umber	1

Oyster White

White	200
Lampblack	¼

Pea Green

White	100
Chrome green, light	3
Raw sienna	1

Peach Bloom

White	12
Orange chrome yellow	1

Pearl Gray

White	100
Ultramarine blue	1
Ivory black	1

Persian Orange

Orange chrome yellow	14
Yellow ocher	5
White	1

Plum

Cobalt blue	6
Alizarin crimson	4
White	4

Poppy Red

Scarlet vermilion	24
Cobalt blue	1

Porcelain Blue

White	18
Prussian blue	1
Light chrome yellow	(touch of)

Primrose

White	100
Lemon chrome yellow	2

Purple

White	1
Ultramarine blue	1
Alizarin crimson	1

Robin's Egg Blue

White	80
Prussian	¼

Rose

White	100
Tuscan red	2
American vermilion	1

Rose Tan

White	25
Burnt sienna	3
Burnt umber	1

Rose Taupe

White	100
Vandyke brown	1½
Venetian red	½
Alizarin crimson	¼

Royal Purple

Ultramarine blue	2
Alizarin crimson	1

Sage Green

White	120
Light chrome green	5
Raw sienna	2
Raw umber	1

Salmon Pink

White	40
Yellow ocher	5
Venetian red	1

Sea Blue

White	25
Ultramarine blue	4
Raw sienna	1

Sea Green

White	5
Medium chrome green	1
Venetian red	(touch of)

Seal Brown

Burnt umber	10
Yellow ocher	2
Burnt sienna	1

Shell Pink

White	100
Orange chrome yellow	1
American vermilion	½
Burnt sienna	(touch of)

Silver Gray

White	60
Drop black	1

Sky Blue

White	300
Cobalt blue	1
Prussian blue	1

Slate

White	100
Ivory black	3
Ultramarine blue	1

Snuff

White	12
Yellow ocher	1
Burnt umber	2

Stone

White	6
Yellow ocher	2
Burnt umber	1

Straw

White	100
Yellow ocher	6
Medium chrome yellow	4

Tan

White	20
Raw sienna	2
Burnt sienna	2
Burnt umber	2

Taupe

White	100
Vandyke brown	1½
Venetian red	½

Terra Cotta

White	100
Venetian red	2
Burnt sienna	2

Tete De Negre

Vandyke brown	20
Drop black	4

Thistle

White	100
Cobalt blue	6
Alizarin crimson	3
Drop black	1
Medium chrome yellow	(touch of)

Violet

Ultramarine blue	1
Alizarin crimson	1

Warm Gray

White	65
Raw umber	1

Watermelon Pink

White	50
American vermilion	11
Rose Lake	1½

Willow Green

White	100
Light chrome yellow	1
Raw umber	1
Medium chrome green	¼

Wine Color, No. 1

White	2
Alizarin crimson	5
Ultramarine blue	1

Wine Color, No. 2

White	2
Rose Lake	5
Ultramarine blue	1

Wisteria

White	30
Cobalt blue	16
Alizarin crimson	6
Drop black	(touch of)

CONCLUSION

Our journey through color's domain now comes to an end. We have wandered far afield, explored many new regions, and re-claimed some that we had temporarily lost. These triumphs, however, are but stepping stones towards greater accomplishments. There are countless more thrills awaiting the inquiring and daring adventurer.

This business of making homes more livable, of enhancing the personal appearance of individuals, of making goods offered for sale more attractive, of improving working conditions, of making the world a better place in which to live through the intelligent use of color, is indeed fascinating. Color is never static — never still and lifeless, but ever changing, ever moving, like time and tide. In this lies its irresistible attraction.

Whoever is concerned with color in any manner or form must surely have found a richness and fascination in the study of the subject as presented in these pages. He will be more alert to beauty, and more rational in his analysis of the sensations of color. He will have gained new conceptions of hue, and will be better able to work out problems in color order and arrangement systematically and scientifically. He will have learned to use his eyes and mind as well as his materials, will see with a new understanding the color renditions of nature, will understand more of what art has attempted to do with color, and will be surprised to find himself endued with capabilities hertofore unrealized. A majestic pageant — a miracle — will unfold before his eyes.

There are those who would have us believe that the days of miracles are passed. But one need not look back longingly to the dim and bygone ages, nor ahead to the dawns of glowing promise for the day of miracles. It is here — now, today and every day of your life, and it is vitally yours. For you have but to open your eyes to "see." That act of vision is a miracle far surpassing understanding — a miracle in which are joined forces and powers utterly beyond comprehension. From the heights you glimpse the glory of a cloudless sky, the misty cool blue of distant mountains, the rolling hills and vales, the verdant meadows from which black-eyed Susans raise their heads, the traffic on the highways, the busy town, the ever-moving ocean with its white-winged sailing vessels and mighty ships of commerce and war. All the works of nature and man — in the fullness of their colorings, are brought to your appreciation by the miracle of vision.

Light reveals, the eyes see, the mind reasons to ask the why, the what, and the whence of it, and YOU "feel" it and are overwhelmingly conscious of its exquisite presence reacting upon the mystical foundations wherefrom life flows.

Until man has fully explored all the mysteries and untold potentialities of the sensation of color and has explained all the miracles of light, he dare not say "impossible" to anything connected with light and color. Their possibilities are infinite. They are yours to use and enjoy.

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